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TABLE OF CONTENTS ON PAGE TWO

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THE JOURNAL OF PROSTHETIC DENTISTRY

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THROUGH THE EYES OF THE EDITOR

Horton D. Kimball discusses the factors to be considered in the control and elimination of chronic tissue soreness under dentures. He divides this persistent soreness according to its cause. Most of the suggestions made for correcting soreness caused by mechanical factors are sound, but some of them are open to question. The suggested use of "softer" acrylic teeth to ease this soreness may be criticized because the very softness will take away from the patient the ability to *detect* a contact *before* the contact is damaging. The use of "flattened cusps" does not insure a reduction of forces applied against ridges, but a reduction of the size of posterior teeth will reduce the force necessary for penetrating food. He might have suggested a method for correction of errors in intercuspation of teeth to accommodate the individual Bennett movements as an additional means for eliminating chronic soreness in some instances. The discussion of the systemic causes for chronic soreness under dentures is quite illuminating. It and the treatments suggested should be very helpful. The one danger is that we do not confuse the two basic causes when the diagnosis is made. The treatment of mechanical causes of soreness will not alleviate that caused by systemic disturbances, and vice versa. We should not hide behind the general physical problems of our patients when denture soreness develops. We should find the real cause. Cooperation with physicians is essential in the diagnosis and treatment for some of these patients.

Edward J. Mehringer discusses the importance of saliva to denture patients. He points out the various ways in which saliva is related to the efficiency of dentures. Two case reports of patients with salivary deficiencies in quality or amount illustrate the importance of saliva in the prevention of irritation under dentures. The treatments suggested seem to give temporary relief, but where the pH of saliva is reduced and the amount of saliva cannot be increased, the prognosis for permanent relief is poor. It is to be hoped that physiologists will take a greater interest in this problem as it relates to denture-wearers. Adequate research may show the way to better solutions than are suggested in this article.

C. S. Kile describes his technique for making full denture impressions which was devised on the basis of his experiences with dentures in his own mouth. He lists the objectives of denture construction in order of their importance as being tissue comfort, masticatory efficiency, and esthetics. It seems that some patients may differ with him in this order. He is certainly correct when he says that proper tissue contact is essential, but there are wide variations in ideas of what constitutes "proper tissue contact." The technique he describes is a variation of a closed mouth impression procedure. The method used for determining the form of the distal end of the upper denture is unique. His suggestion of successive impressions made inside the tray without over-all relief may be open to question, because of the increasing pressures that are built up throughout the entire impression surface, even though the impression material is mixed progressively softer for each insertion. The muscle trimming procedure seems to be a good one for a closed mouth technique.

Howard J. Merkeley discusses the anatomy of the labial and buccal accessory muscles of mastication as it relates to the shape of the polished surfaces of dentures. This study is well-coordinated with practical procedures. He suggests the formation of impressions of the buccal and labial vestibules for the proper formation of the buccal and labial surfaces of dentures. These impressions could also be used to determine the proper location of the occlusal surfaces of the teeth. This is one step closer to the ultimate maximum utilization of anatomy in the building of dentures.

Ralph Carson Appleby discusses the various types of impression procedures for mandibular impressions, and describes his impression technique for making an impression where there has been severe resorption with numerous folds of soft and easily displaceable tissue. He recognizes two bases for differences of opinion. One is related to the amount of pressure used during impression making, and the other is related to the extent of the tissue coverage. His impression procedure is designed to combine the benefits of full anatomic coverage with a minimum displacement of the included soft tissues.

Robert Schermer advises against surgical correction or modification of mandibular ridges whenever it can be avoided by changes in the technical procedures of building dentures. Certainly surgery should not be resorted to unnecessarily. When it is done, it should be kept to the minimum necessary to get dentures in the mouth or to make them comfortable. Some of the technical changes, such as lapping the anterior teeth over the ridge, are open to criticism. The idea that flatness of a lower ridge makes a restoration difficult is not necessarily true. Other factors such as an anteroposterior curvature cause much more difficulty than the mere flatness of the ridge.

I. Norton Brotman shows how roentgenograms can be used during the preparation of teeth for veneer crowns. The procedure permits the operator to have a better knowledge of the tooth he is preparing than simple visual observation will provide.

Ben R. Bronstein points out the fact that a technique for occlusal rehabilitation alone is not enough, but that the basic philosophy of occlusion must be understood for the proper application of a technique. He discusses various concepts of occlusion and arrives at his concept of the optimum occlusal pattern. This concept seems to combine the thinking of those who believe in the importance of bilateral balance and those who believe that centric occlusion is the only occlusal contact. There can be little wrong with an occlusion which is developed to produce the least possible damage under any circumstance. If the recent work of Yurkstas and Emerson (J. Pros. Den. **4**:168-174. 1954) is borne out by other workers, the concept of bilateral balance during mastication cannot be discarded. Bronstein points out the tolerance factor in the use of prosthetic restorations. The tolerance factor is worthy of further consideration. He sets up a set of rules for occlusal rehabilitation which are well thought out. There may be some question of his classification of conditions which require occlusal reconstruction, but the technique which he describes seems to follow sound principles.

Edwin S. Smyd correlates biology and mechanics in his discussion of prosthetic dentistry. This correlation is often overlooked when the chief consideration is the filling of spaces by restorations. The various types of tooth movement under various types of occlusal forces are explained in a logical manner. Some interesting experiments are described to test the effects of these forces. These tests reveal a definite relation between the direction of application of a force and the resultant movement. The differences between interocclusal forces in gliding mandibular movements and cyclic movements of mastication are recognized. The statement that the "anterior thrust of centric occlusion must always occur in human dentition" may be open to question. While this is undoubtedly true in part, the facts of neuromuscular control, and of the effects of the relative position of the mandible, when the closure is started, will modify the *direction* of closure.

R. R. Steinman reports his studies of warpage produced by soldering with dental solders and alloys. The subject is worthy of

further study because of its importance in crown and bridge procedures particularly. Apparently, no consideration was given to grain growth and related problems in this study because they were beyond the scope of this research. The practical requirements of fit or lack of fit of the restoration as a result of soldering make this study worthwhile. A study of other manufacturers' materials is necessary to make this research complete. The effects of various procedures of soldering, investing, preheating, and cooling were studied as well as the effects of different kinds of joints. Four practical suggestions are made for minimizing the distortion as the result of soldering.

Roy L. Bodine, Jr., and Raymond L. Kotch define the relative responsibilities of the prosthodontist and the oral surgeon in implant denture service. Their description of the techniques involved is detailed and clear. They emphasize the importance of adherence to the fundamental principles of oral surgery and prosthodontics. While they say that implant denture service has passed "out of the experimental phase," we believe that this time has not yet arrived. Much more basic research is needed before implant denture service can approach the status of the "conventional" denture service. Clinical evidence alone is insufficient, and the rapidly changing techniques, used by different workers in this field, indicate that the procedures are not yet standardized. The causes of failures which are listed indicate that a policy of wait and learn first is advisable.

Leon Herschfus makes a preliminary report on histopathologic findings on Vitallium implants in dogs. Two types of implant form were used, and after three months the animals were sacrificed, and the tissues around the implants were studied microscopically. No pocket formation or foreign body accumulation was found around the implants. The retentive medium for the implants was found to be periosteal fibers rather than bone. He observes that screws are not necessary for the retention of implants. Much more of this type of research is necessary before the true effect of implants on living tissues will be known. No mention of occlusal contacts or occlusal forces on the implants was made. The question arises, is there a difference of tissue reactions to an implant when it is subjected to intermittent occlusal forces?

Ernest Baden discusses the incidence, diagnosis, and treatment planning for cleft palate patients. He divides congenital malformulations of the lip and palate into the original defect and secondary deformities. The analysis of these secondary deformities should be helpful to the cleft palate team in arriving at a proper diagnosis and treatment plan for a patient. He believes that early palate operations (age 2 to 3) provide better phonetic results than those following operations after the age of 12. If these palate operations are done by surgeons without adequate skill and training, the operations can do more damage than the original defect. Four types of prosthesis for cleft palate patients are described, according to the purpose of the prosthesis. This seems like a logical approach to the problem. The decription of the anatomy and physiology of cleft palate speech is adequate for his purpose and is worth study by those who are interested in cleft palate prosthesis. The use of a radiopaque material on the posterior pharyngeal wall in conjunction with cephalometric roentgenograms should be very helpful in the diagnosis and in the actual construction of speech appliances.

—Carl O. Boucher

FACTORS TO BE CONSIDERED IN THE CONTROL AND ELIMINATION OF CHRONIC TISSUE SORENESS BENEATH DENTURES

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Detroit, Mich.

EVERY DENTIST who does prosthetic dentistry has some patients who are plagued with chronic tissue soreness or sore spots beneath their dentures. Fortunately, most cases of this nature respond to adjustments of the dentures made by the dentist, or the areas of chronic soreness may disappear in time as the thin mucosa covering the alveolar ridges adjusts itself to the stresses and to the load of the dentures, physiologically, by becoming more dense, tough, and fibrous.

Unfortunately however, a small percentage of these people do not respond favorably to the adjustments made on their dentures, and their denture discomfort continues for a protracted period of time. These are the patients who wander from dental office to dental office in search of relief from their troubles; these are the patients who are too often dismissed from the busy dentists' minds with the belief that they are "neurotics," or "hypochondriacs."

It is my opinion that most people do not like to be sick. They do not want to be chronic complainers. They do not wish to bother the busy dentist needlessly with their troubles. Nor do they enjoy waiting in a reception room for a few unsatisfactory minutes of the dentist's time. There are exceptions to these broad statements. In general however, the problem resolves itself into a matter of the dentist determining the cause of the chronic tissue soreness and removing it so the patient is then no longer a "neurotic."

Unfortunately, it seems that much of the procedure of the dentist is predicated upon treating the effect of, rather than the cause of, these conditions. With that thought in mind, it was felt that a systematic approach to the problem would be desirable and helpful.

Obviously it is impossible to provide all of the answers, and many dentists will be able to supply a few more to those discussed in this report. However, some of the factors considered here are not too generally familiar to men doing denture service, and a discussion of them may serve in some measure to stimulate further investigation in this field.

The problem of controlling and eliminating chronic tissue soreness beneath dentures may be divided into two broad categories: *Mechanical Considerations* and *Systemic Considerations* (Table I).

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TABLE I.

CONSIDERATIONS IN CONTROL OF CHRONIC TISSUE SORENESS BENEATH DENTURES

A. *Mechanical Considerations*
   1. Relief of pressure areas inside of dentures
   2. Relief of occlusal trauma and interference
      (a) Spot grinding of the teeth
      (b) Checking of centric relation
      (c) Checking of occlusal balance
      (d) Milling-in of occlusion
      (e) Checking of vertical dimension
      (f) Checking of the occlusal plane of posterior teeth
      (g) Bruxism and bruxomania
      (h) Use of plastic teeth
      (i) Use of modified or nonanatomic posterior teeth
   3. Size of denture bases
   4. Use of soft lining materials

B. *Systemic Considerations*
   1. Drug, antibiotic, and allergic reactions
   2. Debilitating diseases
   3. Systemic conditions associated with endocrine gland disturbances; blood stream disturbances
   4. Nutritional disturbances

Although most dentists are more or less familiar with the details of the mechanical considerations, it is felt desirable to classify and to discuss as briefly as possible these mechanical factors.

It is advisable to make a radiographic examination of the areas of protracted tissue soreness. This is done to determine whether or not surgical procedures are necessary because of unerupted teeth, root fragments, sharp bone spicules, etc.

Assuming that surgical intervention is unnecessary, the approach might be as follows:

MECHANICAL CONSIDERATIONS

1. *Relief of Pressure Areas Inside of Dentures.*—By marking the sore tissue regions with indelible pencil, or any other suitable marking agent, and transferring the marking to the dentures, or by using indicating pastes, soft waxes, etc. inside of the dentures, the areas of excessive pressure may be determined; the dentures are then trimmed or relieved accordingly.

2. *Relief of Occlusal Trauma and Interference.*—A number of factors must be considered in order to be certain that no occlusal interference or trauma is occurring; anyone of these may be sufficient to induce chronic tissue tenderness.

(a) Spot grinding of the teeth.
By use of carbon paper or other indicating methods, premature contacts in centric position and cuspal interference in eccentric mandibular movements may be determined and relieved. Anterior teeth should be checked in both centric and eccentric ranges to eliminate any possibility of interference. Jankelson[10] has devised an ingenious, simple, and effective method of determining areas of occlusal interference by using very thin sheets of wax.

(b) Checking of centric relation.

If centric relation is incorrect, cuspal interference will be present and persistent tissue soreness will probably develop.

(c) Checking of occlusal balance.

Should there be lack of occlusal balance on the balancing side as the patient moves the jaw into working occlusion, the dentures may be dislodged sufficiently to induce tissue soreness.

(d) Milling-in of occlusion.

If centric relation, or occlusal balance are not satisfactory, remounting the dentures on an articulator, and milling them in with abrasive paste will generally correct the condition sufficiently to relieve the tissue soreness that is due to this cause. Checkbites or intraoral tracings for determining centric relation and a face-bow transfer are accepted procedures.

(e) Checking of vertical dimension.

A vertical dimension which is too great will induce trauma and is quite likely to result in a considerable degree of tissue soreness.

(f) Checking of the occlusal plane of posterior teeth.

In setting the posterior teeth, the ridges should be paralleled, so that masticating forces will not "skid" the dentures. Too steep an occlusal incline from the second molar forward is quite likely to produce a rocking effect during mastication. This, in turn, will cause the lower denture to "skid" anteriorly, and frequently results in chronic tissue tenderness, particularly along the lingual region of the anterior portion of the lower ridge.

(g) Bruxism and bruxomania.

Bruxism (grinding the teeth in the sleep) and bruxomania (clenching or gritting the teeth when awake) are habits which, along with the habits of "chewing" and "tripping" the dentures, are often instrumental in the production of tissue tenderness. These habits should be discouraged and corrected where possible. Some of the factors inducing these bad habits are: incorrect centric relation, occlusal interference, too great a vertical dimension, nervousness, ill health, etc.

(h) Use of plastic teeth.

Due to the fact that plastic teeth are softer than porcelain teeth, their use provides a cushioning effect and less trauma to the alveolar ridges. Frequently, the use of plastic teeth is in itself sufficient to relieve chronic tissue tenderness.

(i) Use of modified or nonanatomic posterior teeth.

Flattened cusps tend to reduce lateral interference, and thus they are an aid in reducing displacement and movement of dentures, especially of the lower denture during mastication. Lower posterior teeth with the buccal cusps removed, for example, French's and Sear's teeth, theoretically reduced the stress applied to the lower ridge by approximately 50 per cent, when average foods are being eaten. The "chopping-block" surfaces of the lower teeth have been converted to "choppers" and the upper posteriors have become the "chopping-block." Their cusps have in turn been modified and reduced in height to reduce lateral stresses.

3. *Size of Denture Bases.*—It is easier and more comfortable to sit on the flat side of a board than upon the edge. By the same token, a denture base which covers the maximum available tissue surface is more kind to underlying tissues than one which does not include all the available tissue surface. The same stresses are applied to either the larger or the smaller type of denture base by the patient during mastication. With the larger base, however, the stresses are dissipated over a larger area, hence tissue soreness is reduced.

4. *Use of Soft Lining Materials on the Lower Denture.*—These substances usually require replacement in from six months to one year and are, therefore, not completely satisfactory. The use, however, of a soft lining material on a lower denture may sometimes contribute a great deal to an individual's being able to wear the denture successfully and comfortably. These materials probably aid in "conditioning" some mouths. In time, the tender tissues covering the alveolar ridges gradually change, and develop into a more tough, fibrous, or "calloused" type of tissue which can more comfortably receive the stress of the denture. Generally, after a year or so of wear, the lower denture with a soft lining should be relined or reset in the conventional plastic which, in many instances, is then worn with comfort by the patient.

As a general rule, one or more of these procedures will serve to relieve the average case of chronic tissue soreness beneath dentures.

In some cases these procedures may serve merely to treat the *effect of,* and not the *cause of,* chronic tissue soreness. In some respects, they may be considered simply as palliative measures, and as such, they are not always universally effective.

Under such circumstances a consideration of the systemic aspects of the patient's history may aid in determining the etiological factor or factors responsible.

SYSTEMIC CONSIDERATIONS

It is difficult to develop a systematic approach to the problem from this aspect because so many factors must be considered. Furthermore, there is still much research remaining to be done in this field.

Briefly, some of the systemic factors to be considered are: (1) drug, antibiotic, and allergic reactions; (2) debilitating diseases; (3) systemic conditions associated with endocrine gland, and blood stream disturbances; and (4) nutritional disturbances. Some of these factors may overlap, as will be seen in the ensuing discussions.

1. *Drug, Antibiotic, and Allergic Reactions.*—It has been pointed out by Miller[1] that the ingestion of drugs, such as phenolphthalein and other coal tar derivatives, may create disturbances in the oral mucous membrane and in the gingivae. Certain types of lipstick may initiate an oral inflammation. Dilantin Sodium, which has been used in the control of epilepsy, has sometimes been responsible for the production of a marked gingival hyperplasia. I remember one case where the use of this drug produced a marked hyperplasia beneath the dentures and resulted in a high degree of chronic tissue tenderness which was most difficult to eliminate.

Many drugs act apparently as vitamin antagonists, or antivitamins. They act in various ways to destroy vitamins, to substitute for vitamins in their essential enzyme systems, or to cause excessive elimination of vitamins as described by Miller.[2] Many of these vitamin antagonists act largely on vitamin C or vitamins of the B complex, and their excessive use can cause a marked deficiency. When this occurs, the result may be a sudden onset of marked tissue soreness beneath the dentures.

Some of the more common vitamin inhibitors are: nicotine, alcohol, acetyl salicylic acid (aspirin), barbiturates, morphine, some of the sulfa drugs and some of the antibiotics, such as streptomycin and penicillin.

Relative to allergies, it may be said that many individuals are peculiarly sensitive to certain foods or drugs just as others are to pollen or other particles in the air they breathe. The symptoms may range from sneezing to vomiting, from headaches to hives, and from edema to diarrhea. The oral and denture-supporting tissues may become highly inflamed during such a reaction.

2. *Debilating Diseases.*—Debilating and wasting diseases bring about abnormal metabolic changes in the denture-supporting structures, and may thus have an adverse effect upon denture retention, as discussed by Landa.[3] Chronic tissue soreness may be induced by the shifting and movement of the denture bases, and it is associated with the lowered tissue resistance of the patient.

3. *Systemic Conditions Associated With Endocrine Gland Disturbances and Blood Stream Disturbances.*—In women, there is sometimes a condition of osteoporois which is associated with menopause and postmenopause. Reifenstein[4] is of the opinion that some degree of osteoporosis is almost "physiologic" after the menopause, and that clinical osteoporosis may be found in about 10 per cent of women over 50 years of age. This condition may continue for many years following the menopause. In the later stages of the disease, roentgenographic studies of the spine may show evidence of decreased bone mass or density.

To the best of my knowledge, the association of postmenopausal osteoporosis with chronic tissue soreness beneath dentures has not previously been reported in dental literature. Dr. Massler, of the University of Illinois, has been doing research on the subject of postmenopausal osteoporosis in relation to various dental problems.

In the edentulous woman, such a condition of postmenopausal osteoporosis can readily account for excessively rapid resorption of the mandibular denture-supporting alveolar ridge, and result in chronic tissue soreness.

Because the condition has been encountered with sufficient frequency in my practice, it was felt that a detailed discussion at this point would help to alert other dentists to the disease, and aid them to recognize it when encountered in practice.

According to Reifenstein,[4] some of the clinical symptoms are: a dull, aching, tired feeling in the lower dorsal or lumbar spine, nervousness, weakness, and extreme fatigability. Signs of estrogen deficiency may be manifest; and tissue and skin

atrophy may be present. He mentions further that clinical manifestations of osteoporosis usually appear some time before roentgenographic evidence of the disease is apparent.

Additional clinical symptoms may be: chronic headaches, difficulty in sleeping, and loquaciousness. This latter may be so marked that one would suspect the patient to be a hypochondriac, or neurotic. Frequently associated with the condition are varying degrees of malnutrition.

To further aid in recognizing and diagnosing the disease, it may be well to consider a case: A 49-year-old woman came to my office with the chief complaints of chronic tissue soreness beneath the lower denture and inability to eat a proper diet.

Her history revealed the information that her lower teeth had been extracted approximately ten months previously. After a healing period of a few months, a full lower denture was constructed and inserted; and a partial upper denture was also constructed and inserted. The referring dentist said that it was originally planned to remove the remaining upper teeth also. She had such a severe physical reaction after the removal of the lower teeth, however, that the extraction of the upper teeth was postponed indefinitely.

Both dentures fitted nicely, but she complained of a chronic soreness of the lower jaw which she described as a constant burning, with some aching. She was unable to eat properly, and had lost 15 pounds in weight. She did not admit to any other complaints.

Nutritional deficiencies, with their attendant clinical symptoms, were immediately recognized. In view of the patient's age, the possibility of postmenopausal osteoporosis was also considered. She had had no menstrual periods, bleeding, or spotting for five years. At the onset of her menopause, she suffered from severe hot flashes. She said that she still had them, but they were mild in character. She also said that she took an occasional injection for them at intervals of once a week to once a month. She was in an extremely depressed mental state for a period of five months during the preceding year, which was associated with her menopause. At that time, she was in a sanatorium for three weeks, and had five shock treatments. With this history, a preliminary diagnosis of postmenopausal osteoporosis was made and she was referred to a competent endocrinologist.

I made immediate recommendations to the patient for a high vitamin B complex therapy, and a high protein diet. I also made the recommendation to the referring dentist that the lower denture be lined immediately with a soft, resilient plastic, which would provide more comfort, and enable her to eat an adequate diet.

A thorough physical examination by the endocrinologist revealed the following tests to be normal: urinalysis; blood count; sedimentation rate; blood sugar; blood nonprotein nitrogen; blood cholesterol; blood phosphorus; basal metabolic rate. The following tests were found to be slightly low: blood calcium; alkaline phosphatase.

Roentgenograms of the thoracic spine and of the mandible were made by a

radiologist. He reported a degree of osteoporosis which was sufficient to confirm the preliminary diagnosis of postmenopausal osteoporosis. It was felt that this could well be the factor or cause of her dental problem.

The endocrinologist recommended weekly intramuscular injection therapy of a sex hormone for a period of two months. Following this, she was to take combined estrogen and androgen orally. She was ordered to continue with the vitamin therapy and high protein diet.

In a case history of the nature just discussed, one may readily see the integration of medicine with a specific dental problem. The use of a soft lining material provides the patient with immediate relief from oral discomfort and also aids the patient psychologically. It further allows her to eat an adequate diet so that she may rebuild herself physically. The sex hormone therapy is more of a prolonged type of program and may require a year to correct the condition.

When the dentist is alerted to the condition of postmenopausal osteoporosis, he is able to refer the patient in an intelligent fashion to a physician for diagnosis and treatment. It is my opinion that no attempt should be made by the dentist to treat such conditions, other than to make vitamin and additional nutritional recommendations in cooperation with the physician.

By recognizing such conditions and making certain that the patient receives proper therapy, the dentist has performed a service of immeasurable value and benefit to the patient and to the family of the patient.

It should be realized that numerous other factors such as previous periodontal involvement, trauma, etc. also enter into these cases of extreme resorption. One must rationalize and consider the problems of each patient individually.

Occasionally, the organic changes and nervous conditions brought about during menopause may produce a burning in the oral tissues and beneath the dentures. Where such conditions are suspected to have etiological significance, the cooperation of the physician should be sought.

An uncontrolled condition of diabetes reduces tissue resistance and may result in rapid tissue loss with consequent loosening of the dentures and the development of varying degrees of tissue soreness.

Diabetic patients must be made to accept their responsibility in keeping their blood sugar level as close as possible to normal limits. The dentist constructing the dentures should impress this upon the patient, so that he will not be held responsible for any of the patient's shortcomings. Should there be any question of such a condition in the mind of the dentist, with no supporting evidence from the patient, he should take steps to see that proper blood and urine tests are made, and that the patient receives proper medical attention.

With an upset in calcium metabolism due to a thyroid or parathyroid disturbance, it is possible to have a marked alveolar bone loss, or a chronic tissue soreness, or both.

Secondary anemia will frequently cause the supporting oral tissues to become more sensitive than normal when supporting dentures, and yet there may be no perceptible lesions present.

Clues which may lead to the discovery of any of these conditions may be found if the dentist sends the patient to a clinical laboratory for blood tests. Among the tests found to be of greatest value are: complete differential blood count, blood cholesterol, serum calcium and phosphorus, and total protein. In addition, a blood sugar test, and a sedimentation rate are frequently of diagnostic aid.

Miller[5] in his *Textbook of Periodontia* has an excellent discussion of laboratory aids to periodontal diagnosis. Many of the laboratory procedures are equally helpful in prosthodontic diagnosis.

Any good clinical laboratory will perform the tests, and send the results to the referring dentist. If any of the results are abnormal, the patient may be then referred immediately to his physician for further diagnosis and treatment. Urine tests for sugar, indicative of a diabetic condition, and urine tests for albumin, indicative of renal trouble, and the Sulkowitch test for calcium may also be done by a clinical laboratory. They are very simple tests and may be quite readily done by the dentist in his own laboratory, should he so desire.

Information gained from any of the tests just discussed can prove very helpful in diagnosing certain baffling cases of chronic tissue soreness.

4. *Nutritional Disturbances and Deficiencies.*—Probably the most obvious and frank oral manifestations of nutritional deficiencies are observed in cases of vitamin deficiencies.[6] Deficiencies in B complex reduce tissue resistance, and can be directly responsible for chronic soreness beneath dentures.

The cracking (cheilosis or perlèche) occasionally seen about the corners of the mouth may be due to a riboflavin, B_2 deficiency, and not solely to a closed vertical dimension. In these cases, one 5 mg. tablet of riboflavin given three times daily after meals often proves helpful.

Glossitis (burning tongue) and stomatitis, which may be manifest by burning under dentures, can be due to a niacin deficiency. In such cases, 100 mg. of niacin taken three times daily after meals frequently aids greatly in controlling the condition. Burning tongue is also one of the clinical symptoms of pernicious anemia. A patient whose gall bladder has been removed usually avoids fats, and an oral pellagra may result. This also is a niacin deficiency, and a vitamin A deficiency as well, and is greatly alleviated by massive doses of the respective vitamins.

It is rather uncommon for a patient to have a deficiency of but one part of the B complex, and a safe procedure is to prescribe a preparation containing the entire B complex when deficiencies of this nature are suspected.

A vitamin C deficiency can bring about a form of oral scurvy, which in the edentulous mouth may manifest itself by extreme hyperemia, and in turn may be associated with marked tenderness of the tissues beneath dentures. Such patients usually also exhibit a tendency to bruise very easily. In such cases, one 250 mg. tablet of ascorbic acid given twice daily, after breakfast and dinner, often proves of benefit in controlling the condition.

It should be remembered that vitamins are supplementary foods, and as such should be taken with food in the stomach, preferably during or directly after meals.

Some nutritional deficiencies are far less obvious in their oral manifestations than those just discussed. I have had some interesting and quite gratifying results in a number of baffling cases of chronic tissue soreness beneath dentures by my procedure after thoroughly checking the dietary intake of the patient.

In these cases, the patient was instructed to write down everything that he or she ate or drank, along with the approximate amounts for a period of one week. The dietary intake was then broken down into its component parts.

Six of these cases, with the dietary analysis, are shown in Table II. It should be noted here that these six patients are all women, with an average age of 55 years.

In comparing the dietary intake of each patient with the amounts recommended by the Food and Nutrition Board of the National Research Council, it was found that certain nutritional elements were consistently deficient, as is seen in Table III.

It was found that all were somewhat low on caloric intake, averaging but, 1,430 calories daily. This is a 29 per cent deficiency when compared to the 2,000 calorie daily intake recommended for women by the Food and Nutrition Board, although some nutritionists feel this figure to be rather high, especially in regard to older people.

Other dietary deficiencies of a more severe nature were also observed, however. The patients averaged a 54 per cent deficiency in calcium, 24 per cent deficiency in iron, 43 per cent deficiency in vitamin B_1, 56 per cent deficiency in vitamin C, and a 94 per cent deficiency in vitamin D.

Relative to the deficiency in vitamin D, the book *Clinical Nutrition*[7] says that the need for supplemental vitamin D by vigorous adults leading a normal life seems to be minimum. However, for persons whose habits shield them from sunlight, as well as for elderly persons, the ingestion of small amounts of vitamin D is desirable. It was felt that these patients fell into the latter category.

Although the dietary analyses in Table II showed no apparent evidence of protein deficiency, it was felt advisable to raise the daily protein intake of the patients. According to *Clinical Nutrition,*[8] adequate intake of protein better insures that the tissues will be able to maintain their physiologic efficiency and aids in building tissue resistance to trauma.

Accordingly, these patients were all placed upon a high protein diet. The diet supplied approximately 120 Gm. of protein daily, rather than the 60 Gm. recommended by the Food and Nutrition Board. In addition, they were placed upon a therapeutic quantity dosage of multivitamins for a period of thirty days; after which they were placed upon a minimal daily ration of a multivitamin. It might be further noted that they were instructed to drink at least three glasses of milk daily.

In all of these patients, the tissue soreness disappeared quite dramatically after a period of a few weeks. The patients felt better physically and a satisfactory result was obtained.

TABLE II. AVERAGE DAILY DIETARY INTAKE OF SIX WOMEN WITH CHRONIC TISSUE SORENESS BENEATH DENTURES

CASE	PROTEIN ANIMAL GM.	PROTEIN TOTAL GM.	CALORIES	CALCIUM GM.	IRON MG.	VIT. A I.U.	VIT. B_1 MG.	VIT. B_2 MG.	NIACIN MG.	VIT. C MG.	VIT. D I.U.
1	72	97	1,530	.76	12.3	4,400	.69	1.32	12	44	5
2	28	59	1,480	.40	8.3	3,000	.50	.98	6	23	7
3	24	49	1,260	.23	8.0	6,900	.48	1.10	13	44	36
4	63	77	1,220	.34	8.2	2,700	.38	.76	16	14	26
5	67	89	1,340	.78	12.2	4,500	.67	1.75	41	64	42
6	42	65	1,710	.26	5.6	3,300	.71	.71	9	1	31

TABLE III. RELATIVE DIETARY DEFICIENCIES OF SIX WOMEN WITH CHRONIC TISSUE SORENESS BENEATH DENTURES

	PROTEIN ANIMAL GM.	PROTEIN TOTAL GM.	CALORIES	CALCIUM GM.	IRON MG.	VIT. A I.U.	VIT. B_1 MG.	VIT. B_2 MG.	NIACIN MG.	VIT. C MG.	VIT. D I.U.
Range of cases in Table II											
Minimum	24	49	1,200	.23	5.6	2,700	.38	.71	6	1	5
Maximum	72	97	1,710	.78	12.3	6,900	.71	1.75	41	64	42
Average	49	73	1,423	.46	9.1	4,133	.57	1.10	16	31	25
Recommended allowances for women*		60	2,000	1.0	12.0	5,000	1.0	1.5	10	70	400
Average per cent deficiency		0%	29%	54%	24%	17%	43%	26%	0%	56%	94%

Note: Above averages are close approximations, and are not carried to final decimal places.

*Food and Nutrition Board, National Research Council. Allowances are for women of sedentary type of life. Requirements for animal protein are not listed by the Council.

These patients have since maintained their high protein, low carbohydrate type of diet, and continue to have oral comfort beneath their dentures.

It is definitely not intended to suggest here that dietary control is a cure-all, that will solve all cases of chronic tissue soreness beneath dentures. It is intended, however, to direct attention to this rather neglected phase of the problem with the hope of stimulating further work by others along these lines.

CASE REPORTS

It may be of practical interest and benefit to discuss two clinical cases and the means of arriving at their solutions.

CASE 1.—A woman wearing upper and lower dentures was referred to the office with a sore area beneath the lower denture. The denture was relieved over the area, and the occlusion was checked. A week later she returned with another sore spot, and the denture was again relieved. This was repeated twice more. Then, upon questioning, it was found that she was wearing the fourth set of dentures made in less than ten years. She said that her health had been good until about four years previously when she began having convulsive seizures. Her physician diagnosed the condition as epilepsy, and placed the patient upon Dilantin.

Upon further questioning, however, it was found that she had an extremely poor dietary program. She was unable to eat meat since the mouth was too sore to permit mastication of it. Milk, citrus fruits, and vegetables all seemed to disagree with the patient. Obviously, she was suffering from malnutrition and a dietary deficiency, rather than grand mal, or epilepsy.

She was then sent to a clinical laboratory for blood chemistry tests. The results of the tests showed a low serum calcium, a high phosphorous, and a very high blood cholesterol, as shown in Table IV.

TABLE IV. COMPARISON OF NORMAL VALUES WITH ABNORMAL VALUES FOUND IN BLOOD CHEMISTRY TESTS FOR PATIENT

	SERUM CALCIUM MG. PER 100 C.C. SERUM	SERUM PHOSPHORUS MG. PER 100 C.C. SERUM	BLOOD CHOLESTEROL MG. PER 100 C.C. BLOOD
Values for patient	7.7	4.69	337
Normal values	9–11	3–5	140–190

Suspecting an endocrine imbalance, and realizing the futility of constructing new dentures or of continuing with further adjustments to the old dentures, she was referred to an endocrinologist. After a thorough physical examination, she was diagnosed as having petit mal, associated with a parathyroid disturbance, and dietary deficiency, rather than grand mal, or epilepsy.

She responded rapidly to the therapy, and inside of sixty days the blood chemistry was becoming more nearly normal as can be seen in Table V. The patient was also placed upon a high protein diet with a therapeutic dosage of vitamin supplementation. Over a period of four months, while undergoing treatment with the physician, she required five additional adjustments to the lower denture. She then went for a period of six months without requiring any adjustments to the dentures.

TABLE V. RAPID IMPROVEMENT AND MAINTENANCE OF BLOOD CALCIUM AND PHOSPHOROUS OF PATIENT WHEN PLACED BY PHYSICIAN ON THERAPY OF PHENOBARBITAL, HYTACKEROL, AND HIGH PROTEIN DIET

DATE	SERUM CALCIUM MG. PER 100 C.C. SERUM	SERUM PHOSPHORUS MG. PER 100 C.C. SERUM
Nov. 1951	7.7	4.69
Dec. 1951	8.1	4.2
Therapy instituted Jan. 10, 1952.		
Feb. 1952	9.8	3.4
May 1952	10.85	3.4
June 1952	10.1	3.35
Sept. 1952	11.3	3.6
Nov. 1952	10.6	3.9
Normal values	9–11	3–5

At the end of this time, new dentures were constructed to restore esthetics lost through a closed vertical dimension. She has now worn these dentures for a period of over nine months, with only one adjustment made a few days after the dentures were inserted.

Along with the happy denture results, the patient's physical health and mental attitude have improved vastly. She has gained weight, and has had no more of the "seizures" to which she was once subject.

CASE 2.—A man was referred to the office with the history of having had four upper dentures made. He was unable to wear any of these because of excessive gagging.

Upon examination of the mouth, the most striking thing observed was the extremely thick, heavy, "gluey" consistency of the saliva.

A complete dietary analysis for one week was made, and it was found that out of a 2,400 calorie daily food intake, 75 per cent of the patient's diet was of carbohydrate origin. It was further found that 26 per cent of the daily caloric intake was carbohydrate from alcoholic beverages.

He was immediately placed upon a high protein, high vitamin diet. He was also restricted on sugar, refined grain, and other carbohydrates of a refined nature, and denied any alcohol-containing elements. He was also instructed to drink six to eight glasses of water daily, since he had previously volunteered the information that he drank water only when he took a sip or two as he brushed his lower teeth.

In approximately six weeks, the saliva had changed in consistency from the thick, heavy, mucous type to a thin, watery, serous type, and the gagging had virtually vanished. In addition, he said that he felt better than he had in ten years.

The construction of a satisfactory upper denture then became a matter of simple routine procedure. He has worn the new denture uneventfully for several months with comfort and with no gagging.

DISCUSSION

While these two cases are perhaps more dramatic than those usually encountered, they serve to illustrate a point.

It might be mentioned that the method of evaluating and analyzing the diet as discussed is subject to inaccuracies, since the food quantities are but close approximations as supplied by the patient. This point was discussed personally with Mrs. Ernestine Becker McCollum. She felt that since the dietary inadequacies which were found were so marked and glaring, it would be relatively safe to assume that much the same deficiencies would be found even if the food quantities were carefully weighed.

I have long felt that the dental profession in general, when considering prosthetic problems, has perhaps tended to devote an undue amount of attention toward attempting to solve most of those problems through purely mechanical means. For example, there are various types of posterior teeth, articulators, and face-bows, different impression techniques, numerous methods for obtaining centric relation, etc.

Unquestionably, these mechanical procedures and devices are important, and it is certainly not intended here to belittle their value in prosthodontics. It seems, however, that this trend toward attempting to solve the problems of the prosthodontist through mechanical means has led many to overlook the possibility of obtaining a solution through a physiologic approach.

There are, however, many workers who are directing their efforts along physiologic lines. More so recently, perhaps, than in former years.

To illustrate, Boos's method[9] for obtaining vertical rest position is based upon physiologic principles. Wright[10] and his coworkers have done much to help solve the problems of the patient who wears a lower denture through their physiologic approach in determining proper tongue function. Still more recently, Jankelson[11] and his coworkers have applied physiologic principles to their cinefluorographic studies of mastication and deglutition.

It is to be hoped that the dental profession will alert itself more and more to the possibilities of correlating physiologic and mechanical principles in arriving at solutions to the many problems which arise in prosthetic dentistry.

SUMMARY

An attempt has been made to provide a systematic rationale of approach to the problem of control and elimination of chronic tissue soreness beneath dentures.

While in the light of present knowledge it may be impossible to give the solution to all such cases of tissue soreness, perhaps some of the thoughts and suggestions advanced in this discussion will prove of value in solving individual problems, or might possibly provoke further investigation into this relatively new field of approach to the situation.

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TO TRIM CASTS

The bases of casts may interfere with each other when they are mounted on the articulator. An eight inch carpenter's cutting pincer or end cutting nipper can be used to trim excess stone from the casts quickly and easily.

—*Meyer M. Silverman*

THE SALIVA AS IT IS RELATED TO THE WEARING OF DENTURES

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OCCASIONALLY, prosthetic oddities present such problems that the fabrication of dentures becomes a real challenge, a challenge so intriguing that the issue at hand is obscured or lost. It must be borne in mind that a dental prosthesis serves a threefold purpose. It complements facial esthetics; it is an adjunct to speech; and it is a major aid in mastication. Which of these purposes a prosthesis should serve is best determined by a thorough evaluation of the patient's needs. A critically ill patient, or one who is totally indifferent to esthetic or speech values, obviously is not in need of these considerations. While the need for a masticating aid is important, it is contingent on the patient's ability to wear a prosthesis. The wearing of a prosthesis sometimes causes so many difficulties that its value is questionable.

Formidable prosthetic obstacles are most frequently encountered where: (1) patients are so handicapped physically that they are unable to manage dentures; this class includes patients with any dysfunction of the muscles or accessory muscles of mastication, patients with xerostomia, and patients who have recently undergone a course of deep roentgen-ray therapy about the head or neck; (2) the dentist is required to work under such adverse conditions that dentures cannot be constructed properly as is the case where a bed patient is confined to the home; (3) the patient's mental indifference does not warrant the construction of dentures. In these instances, the endeavor to effect a better nutritional balance by enabling the patient to ingest a more wholesome and a more varied diet is the prime physiologic issue. If the comminution of food material can be accomplished more easily by food choppers, liquifiers, mincers, etc., with less detriment to the patient, than by the patient's ability to manipulate dentures, then the construction of dentures is contraindicted. Dentures constructed under any of the afore-mentioned hazards represent a waste of time and effort on the part of the dentist, and a waste of time and money on the part of the patient. Since the dentist and the patient can ill afford such extravagance, this situation is one of the few remaining thorns in the side of dentist-patient relations.

It is the purpose of this article to discuss some of the factors which enhance the problems encountered in denture construction, factors which may ordinarily be overlooked. The first of these factors is the saliva as it is related to mastication, particularly in the denture patient. Aside from cellular debris and the microorganisms usually found in the oral flora, the saliva is primarily made up

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of two physical components, a serous fraction, or wetting agent, and a mucous fraction, or lubricating agent. The serous fraction acts as a solvent and facilitates the breakdown of the food material during mastication, while the mucous fraction lubricates the bolus prior to deglutition. The parotid gland is characterized by a serous secretion, the sublingual gland by a mucous secretion, and the submaxillary gland by a mixed secretion.

Mastication may be divided into three phases: (1) the actual comminution of food material, (2) the moistening of the bolus, and (3) the lubrication of the bolus preparatory to deglutition. It should be remembered that the absence of teeth does not necessarily preclude the latter two phases of mastication, and that teeth are useful only for the comminution phases. Furthermore, by careful selection of soft nonfibrous foods, teeth are not essential for any phase of mastication; consequently there are circumstances where the construction of dentures for the edentulous patient is ill advised. The saliva, however, is not only essential for the moistening and lubricating phases of mastication, but is also necessary for the retention of dentures under normal conditions. Assuming that the denture base is an accurate negative of the tissues which comprise the basal seat, the denture base resists dislodging because of adhesion, peripheral seal, and traction.

ADHESION

Adhesion is the adherence or sticking together of dissimilar molecules; dentally speaking, it is the molecular attraction between the tissue surface of the denture base and the mucosa of the basal seat when both surfaces are wet with a thin film of saliva. This phenomenon is dependent upon two other factors, cohesion and surface tension of the saliva. Cohesion is the sticking together of like molecules, while surface tension is the resistance to rupture possessed by the surface film of a liquid. The saliva, therefore, should have the ability to wet both tissue and denture surfaces, to be expressed into a thin film without rupturing, and to have sufficient adhesion to attach the denture base to the mucosa. The degree of adhesion is a function of the film thickness; the thinner the film the greater the adhesion. The film thickness in turn is determined by the mucin content of the saliva. A copious flow of thin serous saliva permits a thin salivary film, a thorough wetting of the denture base and the mucosa, and, hence, maximum adhesion, while a viscid, ropy (mucous) saliva cannot be expressed into a sufficiently thin film to provide adequate adhesion. The presence of excessive mucin beneath the denture base behaves much like food debris; it displaces tissue and therefore effects an elevation or rebound of the denture base from the mucosa.

PERIPHERAL SEAL

Peripheral seal is a positive contact of the entire perimeter of the denture base to the yielding tissues outlining the basal seat. This seal is effected only when the entire periphery and the contacted tissues are wet with saliva, and because of the effectiveness of this seal, any dislodging force is resisted by atmospheric pressure.

TRACTION

Traction is the frictional resistance the denture base exhibits to skidding over the tissues of the basal seat. It is due to the intimate apposition of the denture base to the minute contours of the tissues of the basal seat. Any thickening of the interposed salivary film by excessive mucin destroys the intimacy of the contacting surfaces, thereby reducing friction and facilitating skidding.

Since the saliva is so vitally concerned in mastication and in the retention of dentures, it is desirable to obtain some index of salivary function before denture construction is begun. The index used for this purpose is one based on the buffering potential of the saliva.

CHEMISTRY OF SALIVA

Under normal resting conditions, the pH of the mixed salivary secretions ranges from 5.7 to 7.0. However, not all components are secreted at the same pH. Again under normal resting conditions, the parotid secretion varies between a pH of 5.5 to 6.5, while the sublingual and submaxillary secretions combined are decidedly more alkaline, with a pH range of 7.0 to 7.5.

The mixture of all oral secretions imparts a buffering potential to the saliva that is quite unique. Irritants which stimulate the taste buds initiate a reflex action which increases the flow of the salivary glands. Acids in particular elicit an immediate response. Not only is the salivary flow considerably increased, but also the hydrogen ion concentration is depressed as indicated by a rise in pH to a level of 7.5 to 8.0; hence, acid foods are neutralized both by dilution and by buffering. The buffering action of the saliva is so proficient that during the mastication of an apple (pH 3.5 to 4.5) the pulp-saliva mixture will become elevated to a pH of 7.5.

The use of fruit as a salivary stimulant is not convenient, especially for edentulous patients, and for that reason an acid beverage is substituted. The method used to indicate the degree of salivary flow is simple and expedient. The pH of the resting saliva is recorded with nitrazine paper. About 2 to 4 ounces of cola beverage (pH 2.46) are given to the patient to drink and the pH again recorded with nitrazine paper. The average pH of the normal resting saliva is about 6.3, while that of the saliva immediately after swallowing the cola beverage is about 7.5 to 8.0. Should the saliva fail to respond with a rise in pH, a lack of salivary secretion is evident; the rationale is that in order to have an abrupt rise in salivary pH there must be a transient hypersecretion of saliva with an elevated pH, while a lowering of the pH indicates a lack of salivary flow and buffering potential.

Any impairment of the salivary flow or buffering potential necessitates placing dentures over tissues that are in a constant state of mild irritation because of the hyperacidity of the environment. Occasionally, the evaluation of salivary flow will disclose xerostomia, in which case dentures are for the most part contraindicated because tissue tolerance is inadequate, retention is lacking, and solid foods cannot be moistened, lubricated, or swallowed unless the bolus is moistened constantly with a beverage. However, there are extenuating circumstances such as

a patient's youth or the urgency for a cosmetic effect, which demand the construcstruction of dentures. Such situations require heroic measures to keep the dentures wearable even for limited usage. The following case reports are submitted to demonstrate the problems encountered in prosthetic management where xerostomia exists.

CASE REPORTS

CASE 1.—A.K., was white man, aged, 59 years.

History.—Chief complaints were ankle edema of four weeks' duration, dyspnea, and inability to eat. The patient had been admitted to a hospital for the second time because of ankle swelling. He had been hospitalized two years previously for a heart ailment. There was no clear-cut history of rheumatic fever, although he was known to have had a heart murmur for at least ten years. About two years previously, the patient had a cerebrovascular accident, resulting in a partial facial paralysis and loss of speech, and with a loss of sensation of the right arm and leg. The patient had lost a moderate amount of weight in the past two years, and complained of an inability to eat with his present dentures. He had been edentulous for about fifteen years.

Physical Examination.—The patient was fairly well developed but poorly nourished. There was a sensory involvement but no motor involvement of the right arm and leg; there was a residual partial aphasia. Other physical findings were negative with the exception of cardiac and pulmonary symptoms.

Oral Examination.—The patient was edentulous and wore ill-fitting dentures part of the time. The tongue and mucosa were deep red in color, smooth, and severely dehydrated. It was difficult to find sufficient moisture in the mouth to record the pH of the saliva which was 4.5. The drinking of the cola beverage did not stimulate any salivary response as indicated by a drop in pH to 3.0. The nasal septum was deviated, and the nares were atrophied, resulting in frequent mouth breathing which further added to the oral dehydration.

Provisional Diagnosis.—(1) Chronic rheumatic carditis, valvulitis, mitral insufficiency, and aortic stenosis and insufficiency, decompensated. (2) Right pleural effusion. (3) Residuals of left cerebral thrombosis or embolus. (4) Xerostomia, extreme dehydration, and edentulous without adequate replacements.

Prognosis.—Medical prognosis was unfavorable because of progressing cardiac failure. The dental prognosis was equally poor because of the extreme dehydration of oral tissues, lack of tissue tone, and patient's physical inability to manage dentures.

Treatment.—Dentures were constructed and inserted on Oct. 5, 1951 to provide more comfortable dentures bases, to maintain morale, and to retain facial esthetics. However, the patient was unable to ingest anything other than liquids. Five drops of 2 per cent pilocarpine solution were administered before meals, in the hope that salivation could be stimulated. This was ineffective and finally discontinued. A lemon-flavored synthetic saliva was given the patient to sip whenever dryness of the mouth was noticed. This partially alleviated the dryness. Since it was not convenient to carry a bottle of saliva solution at all times, the patient continued to be distressed with dehydration and general soreness about the oral cavity, which persisted through the entire course of dental treatment. The patient developed a lobar pneumonia and died Dec. 25, 1952.

CASE 2.—H.B. was a white woman, aged 50 years.

History.—Chief complaints were canker sores about the mouth, swelling of the lips with fissuring, burning, scaling, and a drawing sensation. The patient stated that she began to develop lesions four months before, at which time a local internist was consulted. After preliminary laboratory studies, he prescribed high potency vitamins, crude liver extract, and B_{12}. There was no alleviation of symptoms in the following four months and the patient was hospitalized for a more complete physical and laboratory examination. A nutritional survey disclosed a diet that was well balanced and replete in whole grains, fresh fruits, and salad greens.

Physical Examination.—The patient was a middle-aged woman, well developed and well nourished, slightly obese, well oriented, cooperative, intelligent, and in no acute distress. She had no physical deformities. The eyes showed slight conjunctival injection, but were otherwise normal.

Oral Examination.—Fissuring of the lips with an acute cheilosis at the angles, moderate swelling, and evidence of desquamation was present. The buccal mucosa was reddened and injected with multiple aphthae about the mucolabial flexure. The tongue was thickened and reddened with papillae present. The entire oral cavity and lips were markedly dehydrated. The maxillary arch was complete with the exception of the third molars. The posterior teeth were badly discolored and heavily restored. The anterior teeth were also badly discolored; all had extensive silicate restorations, which were in a bad state of dissolution. The patient wore a lower partial denture supplying the anterior teeth, the left first molar, and the right first and second molars. Although the remaining lower teeth were badly discolored and heavily restored, they responded to vitality tests. Roentgenograms disclosed no apical pathosis and no significant alveolar or periodontal breakdown.

Laboratory Findings.—The pH of the resting saliva was 4.5, and upon stimulation with the cola beverage it became 4.7, indicating very little buffering response. All other laboratory findings were negative or of no significance; neurologic tests were negative; there were no sensitivities to the usual allergens.

Diagnosis.—(1) Xerostomia. (2) Acute cheilitis with edema, reddening, and desquamation. (3) Aphthous stomatitis. (4) Edema of the tongue, with fissuring and reddening. (5) Conjunctivitis.

Prognosis.—The prognosis in general is good; however, it is doubtful whether the salivary and lachrymal glands will ever return to a normal function, but with the assistance of emollients and sialogogues the mouth in general should be quite comfortable.

Treatment.—The teeth were so heavily restored and so badly discolored that the removal of the upper teeth might reasonably be considered; however, it was decided, because of the lowered oral pH, the dehydration of the oral tissues, and lack of tissue tone, that the construction and insertion of dentures would be too hazardous; it was also decided that keeping the teeth in a good state of repair would be the treatment of choice.

On alternate days the aphthae were treated directly with copper sulphate crystals, followed with a sodium bicarbonate rinse. After eight days of such treatment, the ulceration had healed. The lips were treated symptomatically by frequent applications of cold, wet dressing, immediately followed with 10 per cent boric acid in lanolin to retain the moisture supplied by the wet dressings. The recovery was quite dramatic, requiring only five days. However, the labial fissuring and scaling was prone to recur upon the cessation of local treatment. The patient was advised to continue the wet dressings and emollient as needed.

To induce salivation, five drops of 2 per cent pilocarpine solution were given three times a day, before meals. The dosage was increased by one drop every eight days until eight drops were given, at which level the patient became more comfortable. Stilbestrol was also given since xerostomia is frequently a sequel to menopause. With a slight increase in salivation, the local symptoms disappeared and the patient was placed under the surveillance of her local dentist.

One year later, the patient returned for a consultation. There was no evidence of increased activity of lachrymal or salivary glands since her last visit. The patient stated that she was still dependent on the pilocarpine solution and stilbestrol to remain symptom-free. The following formula was prescribed to stimulate the combined secretions of the parotid, the sublingual, and the submaxillary glands.

Citrocarbonate	2.4
Mucin	.75
Urea	.05
Methyl cellulose	1.2
Oil of lemon	.06
Aqua qs ad	240.

The methyl cellulose was used to retain moisture in the mouth, along with oil of lemon if a flavoring is desired. This mixture provides a moistening, lubricating, and buffering effect during mastication.

The patient was instructed to dilute 2 to 4 tablespoonfuls with an equal volume of water and sip the mixture during mastication or as needed to maintain comfort.

Because of nutritional adequacy, the use of vitamin and mineral supplement was not warranted. The patient was instructed to continue home treatment and to return every four months for consultation.

DISCUSSION

The development of sore mouths after the insertion of dentures for no readily apparent reason can be distressing and perplexing. Often there are no gross lesions, such as those encountered in the traumatic abrasion from an overextended border, but rather there is a general, vague, and fleeting tenderness, one that is never in the same area twice. The reasons given for such occurrences are many; there are idiosyncrasies in relation to the denture base material, occlusal prematurities, incorrect vertical dimension, etc., all plausible and valid explanations, yet without much thought given to the tissue tone and the function of the saliva.

The saliva is a formidable diluting agent; it is secreted at the rate of 1,000 c.c. to 1,500 c.c. daily. Although the average pH range of foods varies from 2.5 to 8.0, the saliva has the remarkable ability to buffer foods during mastication to the narrow pH range of 6.5 to 8.0. The saliva is never secreted at a pH as low as in Cases 1 and 2. However, the depressed pH is the direct result of the activities of acidogenic organisms found in the mouth. The acids formed by such organisms are easily diluted and neutralized by a normal saliva. When the salivary flow is substantially impaired, the buffering factor is largely eliminated and the oral pH is depressed, as seen in both cases. C. H. Williams of Toronto has ably demonstrated that pH is a salient factor in the irritability of nerve endings, which

become increasingly more sensitive as the pH is depressed. This phenomenon reasonably accounts for the hyperirritability of the oral tissues in the cases of A. K. and H. B. Furthermore, with the decrease of saliva the integrity of all irritated tissues is diminished, thus rendering such tissues more susceptible to infection, as was shown particularly in Case 2.

When an excessively mucous saliva is encountered, a normal saline rinse can be used to cut and remove the mucin from the mucosa prior to the insertion of dentures. The tendency toward a ropy saliva is usually the result of dietary imbalance or inadequacy, the adjustment of which, together with a vitamin and mineral supplement, is often sufficient to effect a more normal salivary secretion.

SUMMARY

1. It is prudent to evaluate the degree to which dentures can fulfill a patient's esthetic, speech, and nutritional requirements, for occasionally esthetic and speech factors are of minor importance. While nutritional problems are paramount, they can, when necessary, be surmounted by methods other than the construction of dentures. Where the danger of radiation necrosis is imminent, following a course of deep roentgen-ray therapy, or where any other circumstances contraindicate the construction or wearing of dentures, a balanced mechanically soft diet can be maintained by means of food choppers, food blenders, juicers, etc.

2. Noting the appearance of the oral tissues is of prime importance, since the integrity of the supporting tissues is directly related to tolerance and comfort in the wearing of dentures. Furthermore, when the state of the oral tissues is suggestive of a subnormal salivary function, it is discreet to ascertain the character of the saliva and degree of flow before the natural teeth are removed, where their removal is arbitrary and not a biologic necessity. Because the saliva is essential in the attachment of the denture base to the mucosa, the extraction of teeth for esthetic reasons can be embarrassing and disconcerting if dentures cannot be worn comfortably because of impaired salivary function. The prosthodontist may well regard such signs as redness, swelling, dehydration, and depressed oral pH as hazards and should be cognizant of the fact that the construction of dentures is but a single step in the management of the edentulous patient where such a syndrome exists.

3. The recording of the resting and stimulated salivary pH is a simple and reliable index of salivary function.

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FULL DENTURE IMPRESSIONS

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THE SUBJECT of full dentures deals with one of the oldest problems of dentistry. It was discussed, argued over, and written about long before the cast gold inlay, the porcelain jacket crown, and most of the other branches of dentistry. There have been volumes written on the subject, yet it still remains a very vital issue. The subject is so extensive that it is impossible to go into every phase of it in detail in this article.

The basis of all full denture construction is of course the impression, and I realize that perhaps no phase of prosthetics has brought forth more discussion, claims, counterclaims, praise, and criticism than has full denture impression methods and materials. With this thought in mind I present this article, realizing that much wiser and more experienced men are producing beautiful dentures from impressions far different in technical and procedural detail from those methods which I shall discuss here.

I wish to make it clear and to stress the fact that what I have to present is not adapted to production line methods of denture construction. To paraphrase Mr. Churchill, who had nothing to offer the British people, but sweat, blood, and tears, I have nothing to offer but work, patience, and satisfaction.

My impression method is quite unorthodox, yet I believe it to be the only fundamental change in full denture impression technique since the first plaster impressions were introduced. I believe no other method of procedure or material employed today will record as sharply the detail of the tissues involved, especially the soft palate flexure line, about which so much difficulty, guesswork, and discussion has occurred.

It is not my purpose nor desire to criticize any of the past or present methods or materials; they have fulfilled a need and have assumed their rightful place in the scheme of full denture construction. This is merely my own version of another phase in the development of this important work, with the realization that perhaps someday a newer and better method will be developed.

This method evolved from a desire to ascertain firsthand what my patients were trying to tell me regarding the feel of their dentures. I could not understand their language, nor they mine, so I decided many years ago to gain some firsthand information by building an immediate upper denture for myself. This method developed from my own experience and has been in use for many years, so it is not just another theory.

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While a knowledge of the anatomy involved is basic in the field of full dentures, it is not essential that we remember the names of all the muscles, or their origin, insertion, action, nerve, and blood supply. Regardless of the anatomy, the fact remains that in denture patients there has always been some surgical interference which might have produced some structural and functional change from the ideal. We still have to build the dentures on the remaining tissues.

In constructing a denture that is in harmony with the individual jaw movement and pressure tolerance of the supporting tissues, we must produce a denture base which has proper tissue contact.

ESSENTIALS OF DENTURE CONSTRUCTION

The three essentials of denture construction in their order of importance are: First, proper tissue contact, which means tissue comfort; second, masticating efficiency, which in turn results from proper occlusal balance, and this in turn assists in tissue comfort; and third, esthetics.

PROPER TISSUE CONTACT

We hear much of the post dam area and post damming the denture base appears to be quite a universal procedure, but with my impression method, post damming is unnecessary.

It is not alone the buccal and labial periphery that is important, but the flexure line of the soft palate muscles as well. In fact, this area is probably the most important and has caused no end of trouble and discussion.

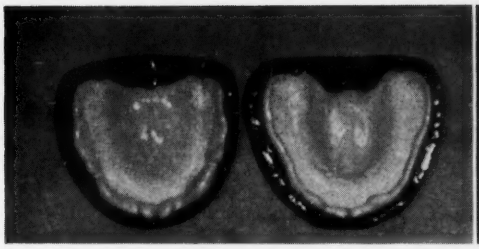
Pendleton[1] recognized the fact that there is "great variation on the two sides as well as in different patients," and showed pictures of "distinct forms of posterior palatal borders." He recognized a great variation in soft palate flexure lines, but as far as I have been able to ascertain, no classification of these variations has been made.

My classification of the soft palate flexure lines is illustrated in Fig. 1.

It is a common belief of the laity, and unfortunately of some of the profession, that the tissues of the mouth, especially the mucobuccal fold tissues, deteriorate after the teeth are lost, resulting in a sagging of the facial tissues and loss of tissue tone. I do not believe this will be the case if the mouth is restored with dentures, which have proper tissue contact and afford proper functional support to the peripheral tissues. I have found that in patients who have worn ordinary dentures where the peripheral tissues have sagged due to lack of proper functional support, these tissues can be stimulated and rejuvenated, and tissue tone restored if they are given proper functional support.

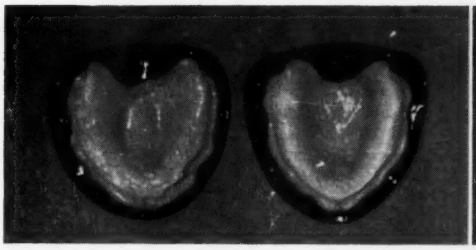
The pressure tolerance of the tissues underlying the denture bases is so variable (not only in different individuals but in different areas of the same mouth) that it cannot be predetermined as some wishful thinkers would assume, but rather it must be determined from actual usage.

With this impression method, the tissues are neither misplaced nor displaced. Fingerprint detail records of the tissues involved are secured during normal



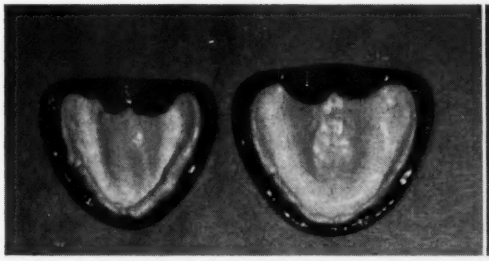
Bilateral tuberosity groove.

Unilateral tuberosity groove.

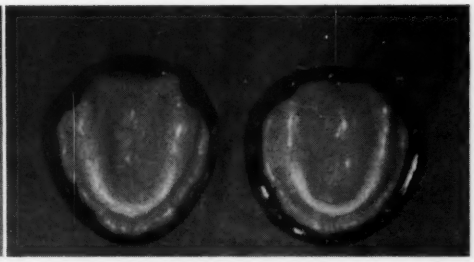


Bilateral extension.

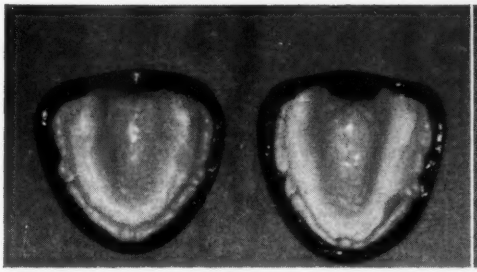
Unilateral extension.



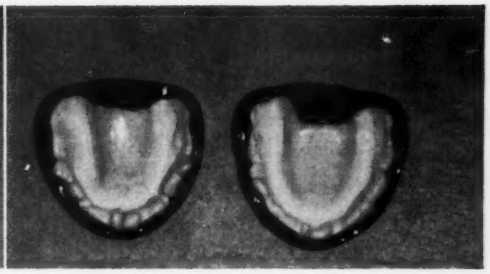
Median line spinous extension.



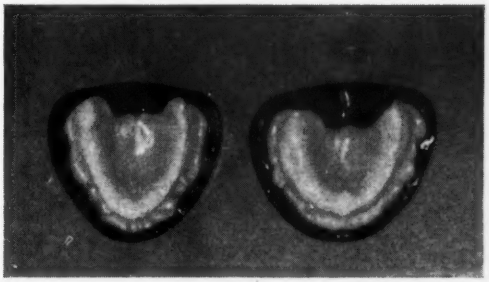
Posterior extension.



Smooth and downwardly curved.



Ragged.



Conglomerate.

Fig. 1.

functional activity. The method is employed with equal satisfaction in immediate denture and partial denture construction.

The muscles involved in mastication, deglutition, speech, etc. perform their movements involuntarily during their normal functional activity; the more nearly we can simulate these conditions during the process of developing the impressions and completing the dentures, the more perfect they will be. The muscles involved in denture construction will contract and be distorted the instant the operator tries to manipulate them arbitrarily. We should remember that we cannot follow our patients around and manipulate these tissues for them as they pursue their daily activities.

Observation will reveal the fact that nothing can be taken into the mouth normally, without the act of inhaling. An individual cannot exhale and take food into the mouth at the same time. It therefore follows that if we can employ this normal muscular movement in a perfectly relaxed and normal manner during the process of developing the impression, we will be able to produce an impression of the tissues involved as they perform normally.

It has been said that it is easy to teach a laboratory technician how to outline the periphery of a denture by drawing some lines on a stone cast; there are gadgets for measuring the depth of the hamular notch. There are also special designs of post dam grooves to be cut into the cast, etc. All of these are purely guesswork.

I believe the only way the peripheral tissue flexure lines can be accurately established is for the tissues involved to delineate their own flexure lines in the impression material during the process of developing the impression. This cannot be induced by any manipulation of the facial tissues by the operator, for the way we think or wish these tissues would perform and the way they function normally are entirely different. In the method I am to describe, the only time the operator touches the patient's face is while the impression trays are being introduced into the mouth.

Time and attention to detail should be important factors in building full dentures, for there can be no substitute for full dentures in an edentulous mouth. I believe too much stress and advertising has been devoted to saving time; a short cut here, a short cut there to save a few minutes of the operator's time—for what? How about saving the crippled patient some distressing time?

THE IMPRESSION TRAY

In order to secure the desired results, we must first have an impression tray that will not inhibit muscle movement and an impression material which is soft enough to record tissue movements without resistance and which will set hard enough so it will not distort in the handling necessary to complete the dentures. In this method, the *original impression* is employed all the way through to the flasking stage.

The impression trays employed are plain blank vulcanite or acrylic bases without handles, but with wax occlusion rims built on them to approximate the

buccolabial contour and the vertical height of occlusion. Shellac base trays are not suited to this technique because they are too fragile and too easily warped.

Experience alone will dictate the peripheral detail required for a satisfactory compound impression for making the tray. Remember that the better the tray impression, the easier it will be to produce a finished impression that will record the correct tissue contact and afford the peripheral tissues proper freedom of movement.

The selected stock tray is lubricated and the compound properly prepared and placed in the tray. After the initial impression and chilling, the stock tray is removed from the compound, and the distal overhanging compound is cut off. Then some compound is traced over the posterior area and the compound impression is reseated in the mouth. This will insure tissue contact at the distal end of the impression. Next, the compound is thinned anteriorly from this distal border, on the tray side. The tissue side of the posterior border is flamed gently and tempered. The impression is reseated in the mouth, and at the same time the patient is instructed to *draw* on your finger as though he were smoking as you hold the compound impression in place. Two or three puffs or draws will suffice. Be particular that the patient does not *suck* on your finger with his tongue, for to do so would raise the tongue and also the soft palate. By having the patient draw on your finger as in smoking, the soft palate muscles will flex downward the same as when food is taken into the mouth.

Upon removing the compound impression from the mouth, it will be observed ordinarily that the softened distal border has been turned down. This turned-down roll is removed with a sharp instrument, and the compound is thinned anteriorly from the distal border on the tongue side. This edge is resoftened and the former procedure is repeated. This is continued until the posterior periphery is just a smooth rounded edge. This method of developing the soft palate flexure line in the compound impression is not generally employed in an impression for a base tray.

THE IMPRESSION MATERIAL

The impression material used is zinc oxide mixed with a hybrid resinous liquid which consists of five parts of Zorite and three parts of Ackerman's fast liquid. These must be measured very accurately and stirred together thoroughly. A quantity of the liquid should be prepared at one time and stored in a suitable container for use as needed. Do not try to prepare it for each mix separately on the mixing pad. Neither of these liquids alone will produce the desired results. The zinc oxide recommended is prepared by Mallinckrodt Chemical Works and supplied through the drug trade. I do not advise using the powder ordinarily supplied with the liquids mentioned, for they are designed for an entirely different impression method. The consistency of the mix is that of heavy whipping cream, but it may be varied for particular uses.

The normal mixing time is about two minutes. One minute is allowed for application to the tray, and about two minutes for the set in the mouth. Atmospheric conditions will influence the set somewhat. The set can be accelerated by the

addition of a drop or two of ordinary bath alcohol to a quantity of liquid the size of a dollar on the pad. The alcohol and the liquid should be thoroughly mixed on the pad before the powder is added. To retard the set, use a drop or two of Zorite liquid in the same manner as the alcohol. The material is mixed on a paper pad in a manner similar to that used for crown and bridge cement. Experience is required to secure the desired consistency, dexterity of application, etc.

The set is gradual, quite similar to that of old salt taffy, and it is about that color and hardness when thoroughly set. It can be whittled or ground for corrections with a vulcanite bur as the impression develops. The volume change is nil, and if the impression is kept in water, it will exhibit no crazing or crumbling over quite a long period of time. It does produce a light "bitey" sensation, but this lasts only a minute or so, and patients seldom remark about it.

THE FINAL IMPRESSION

The position of the patient in the chair is of vital importance. Since we propose to build a functional impression, the patient should be in as comfortable and relaxed a position as possible. The position should, as nearly as possible, simulate the position assumed at the dining table, soda fountain, card table, or office desk, even to getting up and walking around the office. I tell my patients they can do anything but run away. The whole body should be slightly forward in the chair, arms resting on the arms of the chair, with the head inclined slightly forward and *Not* in contact with the chair headrest.

When comfortably seated, the patient is provided with a straight glass hospital tube which has had one end flamed so it has about a 20 gauge opening, and a glass with only a few drops of water in it. The operator should have a tube and glass of his own, in order to demonstrate to the patient just what should be done.

With the impression material in the upper tray, it is carried to the mouth and jiggled lightly into place. The lower occlusion rim tray is then seated, and the patient is instructed to close and then click the jaws together a time or two. This not only seats and positions the upper tray, but it also relaxes the muscles.

At this point the patient is handed his glass and straw and is instructed to take a few draws on the tube as though it were in a glass of lemonade. The small amount of water in the glass will produce a gurgling sound which is for its psychologic effect; the sound also allows the operator to know whether or not the patient is doing as instructed. After a draw or two, the patient is instructed to remove the straw from between his lips, close and swallow, then spit. These are all normal functional activities. This procedure is repeated and continued until the impression material has stiffened sufficiently so the tissues cannot move it.

The upper tray is left in position in the mouth and the lower tray is removed, washed, and dried. Then a fresh mix of the impression material is applied to the lower tray, and it is seated in the same manner as the upper. The patient is instructed to follow the same routine as with the upper impression except that before spitting, he is asked to lick the material from the corners of the mouth

(which has been left there accidentally on purpose as the tray was introduced), suggesting that it is pie, watermelon, or some sort of food. The patient usually laughs, and the tongue immediately goes into action, which in turn molds the lingual borders of the impression.

The patient is directed to repeat this procedure until the material has set. Do not attempt to loosen the impression bases manually, but instead, give the patient a glass of water and have him rinse the impressions loose. The operator can assist with a spray applied along the mucobuccal fold.

After the impressions are removed from the mouth, they are washed in cold water, blown dry, and examined for pressure areas which will be evidenced by the tray's showing through the impression material. These areas must be relieved, then a new mix of impression material is applied to these spots. The impression is immediately returned to the mouth together with the opposing one, and the routine impression procedure is carried through. This is repeated with the lower impression, then both are re-examined for pressure areas. The entire routine procedure is repeated until all of the pressure areas are corrected, and there are no spots where the tray shows through the impression.

Peripheral borders that are short will appear as tapering out to a paper thin edge. These edges should be supported by backing them up with baseplate wax before adding new impression material; then proceed in the same manner as for relieving the pressure areas. Experience alone is the only means of knowing when the impression is correct.

After all of the pressure areas have been properly relieved and spotted out, a thin overlapping of the impression material may be observed. This overlap should be removed with a scraper, and the area smoothed over with a pledget of cotton moistened with Energene. When the impression is dry, a fresh but somewhat thinner mix of the impression material is made and painted over the entire surface of the impression. The thin mix is painted on the impression with a short stiff mucilage brush. When the brush marks have smoothed out, the impression is inserted in the patient's mouth and the previously followed routine procedure is repeated.

When the new material in the upper impression is set, the lower impression is perfected in like manner. When all of the impression material is properly set, the patient is instructed to rinse the impressions loose as before. A truly functional impression to fingerprint detail will result.

Compound impressions for trays for the immediate denture patient are made in the same manner as for the edentulous patient. The tray for the immediate denture impression is built around the remaining teeth so that they protrude through the tray. This preserves the original centric relation and vertical dimension.

The same method is used for developing the final immediate denture impression as for the edentulous impression, except that when the final impression of the ridges and the labial flange area is completed, any impression material extending between the remaining natural teeth is removed. Then, an alginate im-

pression of the teeth that protrude *and* the adjacent tray is made in a tray of suitable size. The alginate impression is removed first, then the impression of the ridge is removed. After the alginate has stiffened somewhat, it is removed from the metal tray and reassembled on the ridge impression tray.

THE CAST

Tin foil is the ideal material over which to cure acrylic, so, when the impressions are finished, they are boxed in Gelum, and foiled with .0005 tin foil before the cast is poured. The tin foil makes it possible to separate the impression from the cast intact, so the impression can be used in completing the dentures. This eliminates the necessity for building a trial base and making it fit by means of a stabilizing paste.

When the impression and cast are separated, the tin foil is stripped from the impression. After the impression is cleaned with Energene, it can be replaced on the cast, and it will also fit the mouth. This, however, is not the only reason for tin foiling the impression.

By tin foiling the impression, its size is thus reduced by the thickness of the tin foil used, then after the denture is flasked and the wax eliminated, the cast is foiled with .0005 tin foil. This restores the cast to the original size of the impression, but with the protection of the tin foil.

SUMMARY

This technique may sound quite complicated and impractical, but in reality it is quite simple. It will produce astounding results with much pleasure and satisfaction to both the operator and the patient. This after all is what we should be striving for, and I only promised you work, patience, and satisfaction.

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THE LABIAL AND BUCCAL ACCESSORY MUSCLES OF MASTICATION

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IF PROSTHODONTICS is to remain an integral part of dental practice, it would seem the part of wisdom to give our final year students an added course in each of four subjects. These are applied physics, applied physiology, applied psychology, and certainly, applied anatomy. Dissection of the muscles of mastication, both essential and accessory, would necessarily form part of the latter course.

Fish[1] has impressed upon me the necessity for making positive use of certain muscles to gain denture stability and retention. He maintains that treating them negatively is not enough.

Let us for a short time review the anatomy of the masticatory machine. It consists of a fixed and a movable member. The movable member is activated by a series of voluntary muscles, and its efficiency is increased by another set of voluntary muscles that feed the machine. As prosthodontists, we are chiefly concerned with the activating muscles from the standpoint of their power and the load they may impose upon the tissues under a saddle that supports an artificial replacement for lost teeth.

Let us now discuss the muscles that feed the masticating mill. Their chief point of interest to us arises from the fact that they can be tensed independent of the relation of the mandible to the maxilla. Also, they impinge not only on the denture borders, but also on the polished surfaces of dentures. So, they immediately become of prime importance in securing denture stability. During impression making we must be actively aware of their location and direction of action, as well as their effect. They, like the power group of muscles are very frequently synergistic in action. Natural evolution did not consider the intrusion of the dentist to replace lost organs, so no preparation was made to assist him. Thus many and varying problems and hazards must be faced for each successive patient who presents himself for the replacement of his teeth.

Let us for a moment follow in detail the consecutive steps in muscle movement when food has been placed into the mouth. First, there is a drawing together of the lips (a pursing), following which the muscles at the corners of the mouth tense, thus keeping the food in the buccal area from escaping in a dribble. Then the food in the buccal area is forced upward and held upon the occlusal surfaces by the cheek. Meanwhile, on the lingual side of the teeth, the tongue also forces the food to, and holds it upon, the occlusal surfaces of the

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teeth. Some of the food may lodge temporarily in the buccal area below the gingival margins of the molar teeth while waiting its turn in the mill.

During mastication, serous saliva from the parotid glands is poured into the buccal areas (from the region of the upper first molars), while the lingual salivary glands on the lingual side of the lower teeth pour in, not only a serous, but a mucous secretion as well. This latter is the lubricant that enables the bolus of masticated food to slide readily to a position where it can commence its passage to the stomach. Mastication time varies with that habit of the patient, but when it is completed, a new series of muscles come into play. The teeth come into occlusion or to rest upon the bolus of food, the cheek is tensed against the teeth, and the tongue tip is forced firmly against the anterior palate to push the food backward. Gradually, the pressure of the tongue is asserted more posteriorly on the palate until the distal of the middle third of the tongue presses hardest, thus forcing the food into the throat area where the muscles close above it and it passes beyond our field.

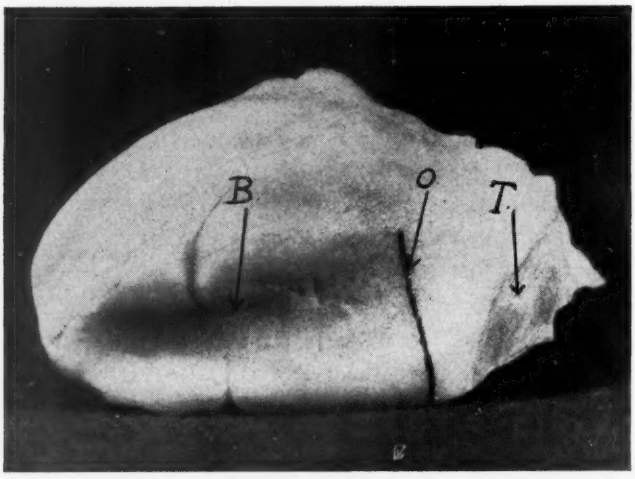


Fig. 1.—Impression of the right vestibule with the lips well protruded. *B*, Buccinator groove. *O*, Location of the mesial surface of the lower first molar. *T*, Depression made by the triangularis muscle.

ACTION OF THE ACCESSORY MUSCLES OF MASTICATION

A number of approaches were made in an effort to analyze the exact location, effect, and various and changing applied action of these accessory masticatory muscles, during the masticatory cycle. First, many feet of slow motion pictures of the activities of these muscles during mastication were taken. Study of these pictures disclosed the fact that the essential movements of the lips were protrusion and retrusion, with an accompanying inward movement of the cheeks in the bicuspid and the molar regions sometimes in unison.

The second approach to the problem was a series of four right vestibule impressions made in the same mouth. (The subject had natural dentition.) The teeth were barely occluded, and the impression material was very plastic.

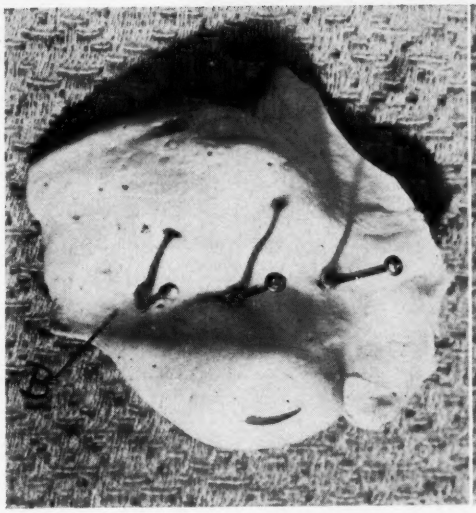


Fig. 2.

Fig. 3.

Fig. 2.—Impression of the right vestibule with the lips well protruded. The pins perforate the bottom of the buccinator groove.

Fig. 3.—The reverse side of the impression in Fig. 2. Note the position of the pins in reference to the occlusal surfaces of the teeth.

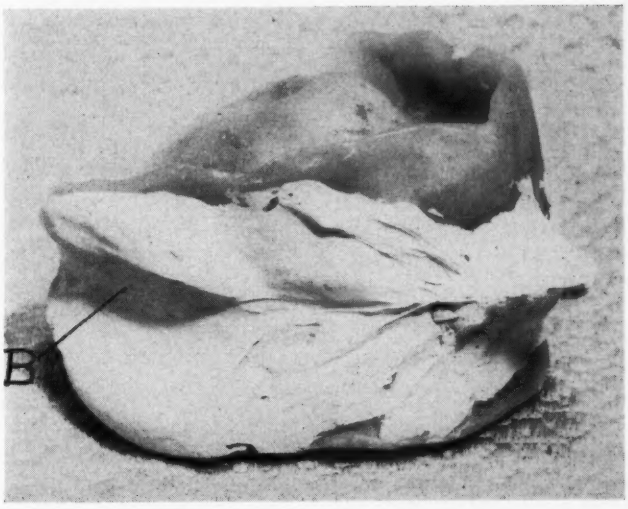


Fig. 4.—An impression of the buccal vestibule with the wax trial bases in place. *B*, Groove cut by the taut buccinator muscle.

The first impression was made with the lips well protruded, and so maintained until the impression material had set (Fig. 1). The impression showed (1) a deep horizontal groove that had been made by the horizontal fibers of the buccinator muscle when they were stretched during lip protrusion, and (2) a triangular depression where the stretched fibers of the triangularis muscle impinged on the impression material. Of great interest to the prosthodontist was the fact that the bottom of the groove cut by the buccinator muscle proved to correspond with the occlusal plane (Figs. 2 and 3). This suggested a simple method of locating the correct position for the occlusal plane for full dentures. We simply make a bilateral vestibule impression with the trial bases in place and very lightly occluded, and with the lips well protruded. The bottom of the groove cut by the buccinator muscle is perforated by a line of holes reaching into the wax base, and the occlusal plane is adjusted to this line of holes (Fig. 4).

The second vestibule impression was made with the corner of the mouth well puckered in, that is with the modiolus tensed (Fig. 5). This second impression showed the imprint of the tensed triangularis muscle, as well as the partially tensed buccinator muscle. The depression made by the triangularis muscle would suggest a narrowing in of a denture in the lower bicuspid region, especially in the presence of a small oral cleft.

The third vestibule impression was made with the buccinator muscle tensed, that is, with the corner of the mouth drawn well back. This showed the well-defined imprint of the buccinator or suctorial pad (Fig. 6).

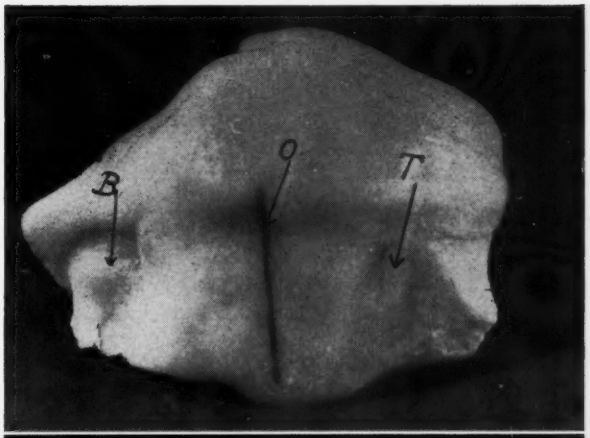
The fourth vestibule impression was a composite of the three others; that is, there was a forcible alternate protrusion and retrusion of the lips. This registered the muscle action in movements that simulated those during the cycle of mastication (Fig 7).

PRODUCING LABIAL AND BUCCAL CONTOURS

This suggested that an impression for a full lower denture should be poured so as to produce some of the characteristic buccal and labial contours. It is not enough to reproduce the borders only. For very flat lower ridges we approach the matter in a different manner. We reline the baseplate with the teeth set up at the try-in stage. The teeth are maintained in light occlusion while the forcible protrusion and retrusion of the lips is executed as long as the impression material is plastic. The excess of the reline material flows onto the labial and buccal surfaces of the trial dentures, and is, of course, molded to the basic contour of the cheeks and lips. The excess is trimmed away and modified as indicated, and the denture is finished. Another great advantage of this step is that any undetected tipping or other displacement of the lower trial denture when it is occluded can be corrected. This tipping and displacement when teeth are occluded is a very frequent cause of lower denture failure.

FORMS OF BUCCAL SURFACES OF TEETH

Considerable interest has been manifest in occlusal forms for teeth, but the buccal forms have been neglected almost entirely. Certain buccal forms of natural



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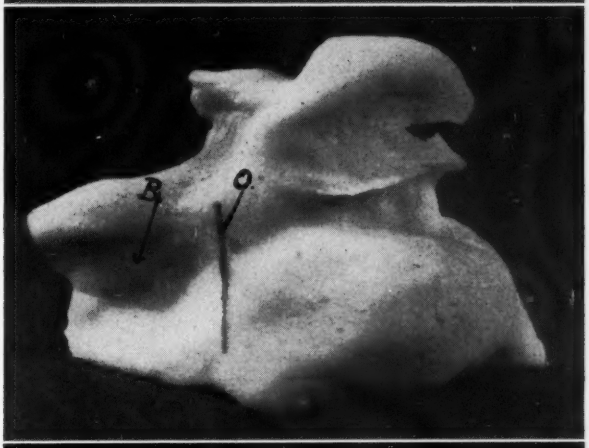

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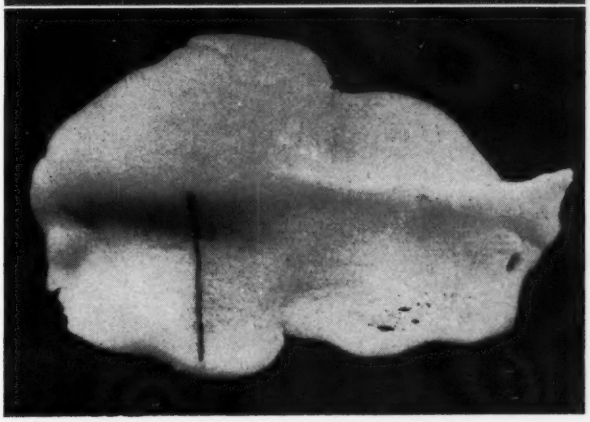

Fig. 7.

Fig. 5.—An impression of the right vestibule with the triangularis muscle tensed. *B*, Buccinator depression. *O*, Location of the mesial surface of the lower first molar. *T*, Depression produced by the triangularis muscle.

Fig. 6.—Impression of the right vestibule with the buccinator muscle firmly tensed. *B*, Buccinator depression. *O*, Location of the mesial surface of the lower first molar.

Fig. 7.—Impression of the right vestibule which is a composite of the other three impressions.

molars and bicuspids may, I believe, be a large factor in producing buccal caries. While in lower dentures, failure to fashion buccal tooth forms properly lessens stability and produces food packs in that area. In an effort to discover suitable buccal forms, a buccal vestibule impression was made in a mouth with a natural dentition with the lips protruded, and with the teeth not occluded. This impression was poured in such a way as to reproduce both sides, that is, the teeth as well as the form of the taut buccinator muscle were reproduced. A hole was drilled through the reproduction of the buccinator groove on a line parallel to the line of its lower slope, and a pin was inserted. The angles were measured and a drawing was made (Fig. 8).

ANATOMIC ANALYSIS

The horizontal fibers of the buccinator muscle have their origin from the pterygomandibular ligament and, passing buccally and forward, they are inserted into the orbicularis oris muscle. In passing forward, they belly outward and downward so when drawn taut or when tensed they sweep upward and inward at an angle of 45 degrees as seen in Fig. 8.

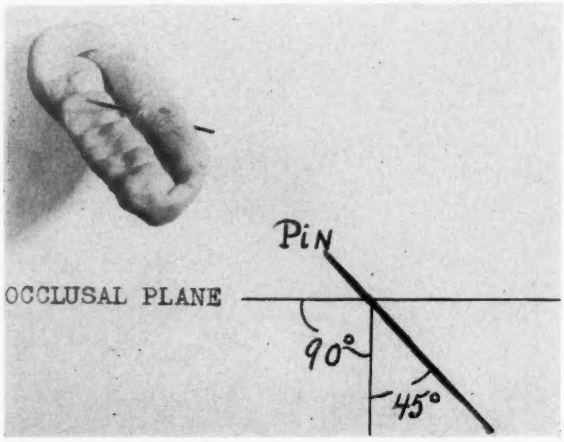

Fig. 8.—A cast made from an impression of the right vestibule showing the teeth and their relation to the taut buccinator muscle. The pin shows the direction of movement of taut horizontal fibers of buccinator. The drawing shows the angle of the pin to the occlusal plane.

As a final approach to an analysis of the accessory muscles of mastication, two dissections were made and the muscles of one dissection were painted various colors with oil paints. Colored slides and photographs were made (Figs. 9 and 10).

A paper pattern was made of each of the three layers of muscles, including the masseter. Stove pipe wire was bent to the outline of the paper pattern, and the three layers were braized in their proper relation to each other. The muscles were stripped off of the skull, and the wire outline was laid on it in the correct position. The more superficial wires were painted white where they crossed the deeper ones. This reconstruction was photographed (Fig. 11). By

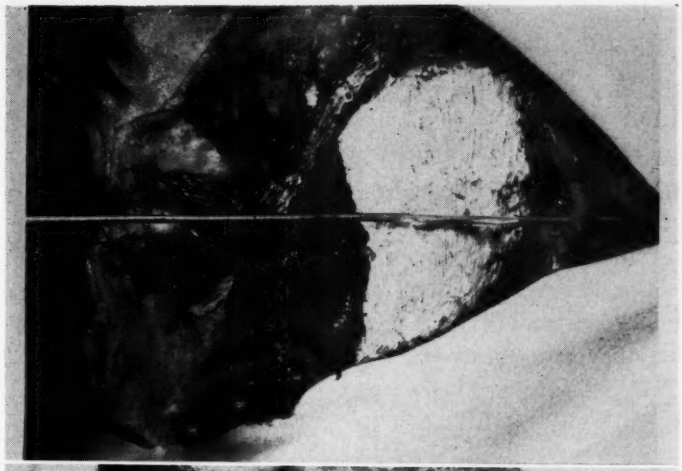

Fig. 9.

Fig. 10.

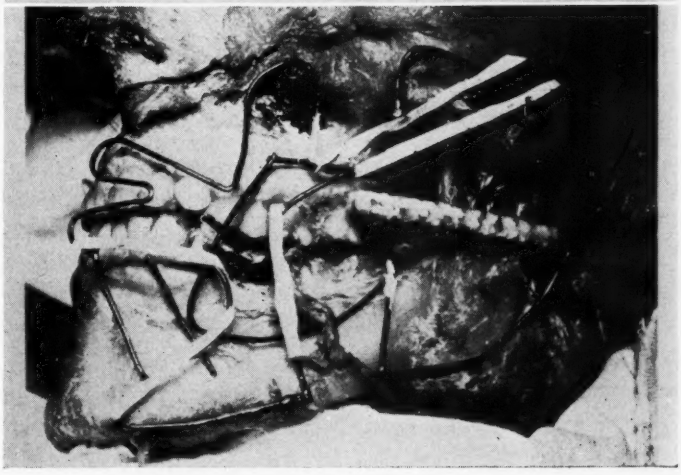

Fig. 11.

Fig. 9.—A dissection of the lip and cheek muscles painted with oil paints. The wire indicates the level of the occlusal plane.

Fig. 10.—Dissection of the lip and cheek muscles. *OO*, Orbicularis oris. *DLI*, Depressor labii inferioris. *T*, Triangularis. *B*, Buccinator. *Man*, Bare surface of mandible. *FA*, Facial artery. *SD*, Stensen's duct. *Z*, Zygomaticus. *C*, Caninus.

Fig. 11.—Wire outlines of the muscles of the lips and cheeks (Fig. 10) superimposed on the skull after the muscles were removed. Stensen's duct is shown by a pipe cleaner. The facial artery is natural.

this means it was very easy to see the relation of the various muscles to each other and to the teeth, by simply looking through the wire pattern.

The information gained by this analysis can be very useful in developing a technique for better denture service. Anyone wishing to further explore the possibilities of the procedures which have been described can gain a great deal of valuable information by making the suggested series of four vestibule impressions of his own mouth with a very plastic material. The results will be amazing when they are examined.

The muscles on the lingual side of the ridge will be discussed and depicted in a rather unique and simple manner in a future article.

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A MANDIBULAR IMPRESSION TECHNIQUE FOR DISPLACEABLE TISSUE*

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PROBABLY NO OTHER phase of complete denture construction has been more discussed than the making of impressions; dental literature abounds with many different ideas on the subject. This article is dedicated solely to discussing the making of an impression for the mandibular arch where there has been severe resorption with numerous folds of soft and easily displaceable tissue.

An impression is a negative registration of ridge and border tissue accomplished by one or more impression materials. It is a record of these tissues taken while at rest or in a displaced position.

The four basic fundamentals of impression making which the prosthodontist seeks to achieve are: (1) areal coverage, (2) periphery, (3) valve seal without interference with functional movements, and (4) accurate adaptation to the tissues without injurious displacement. I have kept these four points in mind while reviewing the literature; it is the achievement of these same points which is the aim in technique to be described.

There are two schools of thought on the subject of pressure impressions. One group advocates pressure throughout, the other stresses minimum pressure. There are also two schools of thought on extension of dentures. One teaches full coverage and extension, whereas, the other contends that only slight capping of the ridge is sufficient. There are, therefore, two fundamental differences of opinion: pressure versus nonpressure, and full coverage and extension versus minimum extension.

PRESSURE VERSUS NONPRESSURE TECHNIQUE

In recent years, a new and fascinating word, mucostatics, has been coined in prosthetic literature by Page.[1] Page has assumed the role of the founder of a new idea, the nonpressure type of impression. However, upon review of the literature, it is found that as far back as 1886 a dentist by the name of Richardson[2] was advocating the use of plaster of Paris as a means of making an impression which least disturbed the tissue while at rest. Credit should be given Page for reviving the interest in, and importance of, the nonpressure type of impression; the fact remains that the real credit for such a technique must be given to Richardson. He and other early teachers used plaster of Paris in well-shaped trays. When it was necessary to alter the tray in any way, it was accomplished with wax or modeling compound.

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Patella,[3] an advocate of nonpressure impressions, believes that retention of the denture and comfort to the patient are achieved when the denture base is in contact with relaxed and undisturbed soft tissue. Stansbery[4] states that "compression causes a diminution of vascular content, and the contents of the veins and arteries having been expelled, the normal tissue balance is disturbed." Stansbery and many others believe that a denture base material constructed to fit a pressure type impression fits well when the tissues are under stress, but when the tissues are relaxed during the time of nonuse, the denture will loosen, due to the fact that the blood re-entering the vessels alters the tissue contours and therefore causes loss of denture base and tissue adaptation.

DeVan[5] sums up the theory behind the nonpressure type of impression when he states: "The facts in support of the theory of rest impressions are irrefutable, the facts are these, (1) the laws of hydrostatics tell us that water is incompressible, i.e., you cannot take a given amount of water and through pressure reduce its volume, (2) the mucoperiosteum is a semi-solid with over 80% of water as its composition, and utilizing the known facts of hydrostatics, the mucosa is incompressible by any force that the muscles of mastication are able to deliver, (3) while the mucoperiosteum cannot be compressed, it may, however, be displaced in the absence of confining walls, (4) any substance, no matter how fluid, when enclosed in a rigid container, takes on the same rigidity as the container, thus soft tissue, provided it is completely contained, would under these circumstances become as rigid as bone, (5) tissue is elastic and will not remain passive in a displaced position. Tissue will try to recover its unstrained rest form."

These facts have been discussed many times in dental literature by well-informed prosthodontists, who agree that they are sound principles which cannot be overlooked when making an impression.

In direct opposition to the preceding theories are those of the pressure type impression group. The Green brothers,[6] Pendleton,[7] Frankewicz and Gobby,[8] and others, all advocate the pressure type of impression.

The principle upon which this group bases its belief is that the denture-supporting tissues should be displaced when the impression is made because these tissues will be in a displaced state during mastication. That the tissues are displaced during mastication is unquestionably true, but it is believed that they have overlooked several very important basic factors. One of these is that when soft tissue is displaced, either one of two things will result. It seems reasonable to assume that the displaced tissue will tend to return to its normal rest position, at least at first, and in so doing it will dislodge the denture base, and the denture will no longer have perfect adaptation to the tissue. When this tissue becomes fatigued or has lost its power to resist, a condition of pressure atrophy will result, and as long as pressure is brought to bear upon it, atrophy will continue until the tissue has been forced to accommodate the denture. The denture base should have been constructed originally to accommodate the tissue.

Another fact that is possibly overlooked by this group is that out of the twenty-four hours of the day, the denture-supporting tissues are under the stress of mastication for only two or three hours, at most. These tissues are not only

undergoing a considerable strain during two to three hours of function, but during the other twenty-one or twenty-two hours of the day, they are trying to regain their unstrained rest position. Denture displacement and/or pressure atrophy is continually taking place.

It is granted that the tissues under the nonpressure technique denture are displaced during the two or three hours of mastication, but during the remaining hours of the day, they are in their natural rest position and the denture is maintaining one of its important functions, that of tissue adaptation, and the blood supply to the tissue is not encroached upon.

For these reasons, it is believed that the ideas presented by the nonpressure group are the ideas of choice.

FULL COVERAGE AND EXTENSION VERSUS MINIMUM EXTENSION TECHNIQUES

The group advocating minimum extension, as represented by Albinson,[9] Page,[1] and Dykin,[10] believe that the flange of a denture need be no more than the type of flange represented by the flange on the wheel of a railway car; their belief is that denture retention is obtained by what they term interfacial surface tension.

This term does not seem to appear elsewhere in prosthetic literature, except when it is used by those asking for its clarification. Pryor[11] states: "Being unfamiliar with dental literature and experience in good denture practice, the salesman immediately promulgated some theories which cannot be accepted by thinking prosthetic men.

"He stated that the profession had accepted atmospheric pressure as the only factor in denture retention, but that the discovery of 'interfacial surface tension' was responsible for it. This is an error.

"The profession had for years accepted the term adhesion or adhesion by contact . . . [as] the chief retaining force."

Dental literature abounds with articles by men who think, as Pryor does, that more is needed than merely capping the ridge and a minimum flange extension for a satisfactory denture service. This becomes more apparent as analysis is made of the thinking of the men who advocate maximum coverage and flange extension. The names of the men who comprise this group are legion, and mention of but a few is made here: Pryor,[11] Swenson,[12] Wilson,[13] Boucher,[14] Roberts,[15] Tench,[16] and Smith.[17]

If the reasoning of this group were summarized, it would demonstrate that they believe in:

1. Covering as much denture-bearing area as is possible. Their reasoning is to provide as great a denture-supporting area as possible, and to more equitably distribute the load.

2. A well-defined periphery which will extend to, but be within the limits of tissue tolerance. This will gain for the denture lateral stability and valve seal, which are other aids in denture retention. This brings up the point of atmospheric

pressure which may be utilized for denture retention, but only through the medium of a vacuum chamber. This vacuum chamber is what is commonly referred to as the emergency vacuum chamber. It is realized only through the medium of areal coverage and peripheral adaptation and extension upon, yet short of interference with, the surrounding soft border tissue. There is a so-called suction produced by the emergency vacuum chamber when a force tending to dislodge the denture exhibits itself, and this suction will exist as long as the force is applied, or until air can gain access to the vacuum space.

3. Accurate adaptation to the tissue without injurious displacement. This accurate adaptation of the underlying tissue provides another important principle in denture retention which is adhesion by contact. It is a simple matter of adhesion and cohesion. Adhesion is the attraction of unlike molecules, for example, the denture base material to the saliva, and cohesion is the attraction of like molecules, for example the molecules of the saliva.

The following mandibular impression technique is based upon the preceding theories. It is one which has proved clinically to be the technique of choice for the patients who present the typical flat ridge covered with soft, easily displaceable tissue.

THE IMPRESSION TECHNIQUE

One of the important parts of impression making is the preliminary mouth examination, which should include a complete radiographic survey, visual and digital examination, and a notation of the patient's denture history. The history should include comments on the patient's mental attitude, a point which is often overlooked. It should be stressed that a written as well as mental record of these findings be made.

Using a stock metal tray which will afford full coverage of the denture-bearing area, a primary compound impression of the lower arch is made (Fig. 1). To make an acceptable primary impression, certain anatomic landmarks must be visible, such as the residual ridge, retromolar pads, the external oblique ridges (including the buccal shelves), mylohyoid ridges, and the labial and the sublingual gland portions of the residual ridge. The genial tubercles may be quite prominent.

After an acceptable primary impression is secured, the lingual portion of the impression is boxed in with sheet wax. This wax prevents plaster from flowing into the lingual area of the hastily poured up plaster cast, which is made for the purpose of constructing an individual quick-curing acrylic tray.

The finished plaster cast (Fig. 2) is outlined to an approximate 2 to 3 mm. underextension from the extension anticipated in the finished denture. This underextension should afford sufficient space for muscle trimming the borders. Anatomic landmarks that will prove helpful in outlining the cast are the retromolar pads, the external oblique ridges, and mylohyoid ridges.

One thickness of baseplate wax is adapted and cut to this penciled outline (Fig. 3). With the aid of a stone mold, quick-curing acrylic is prepared and adapted to the wax shim on the plaster cast (Fig. 4).

Fig. 1.

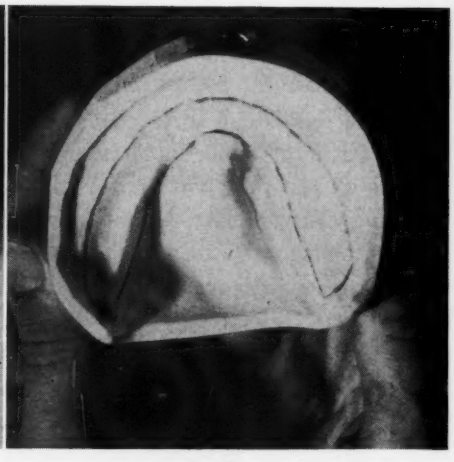

Fig. 2.

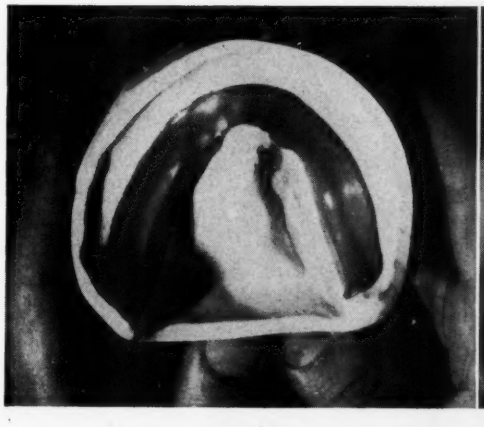

Fig. 3.

Fig. 4.

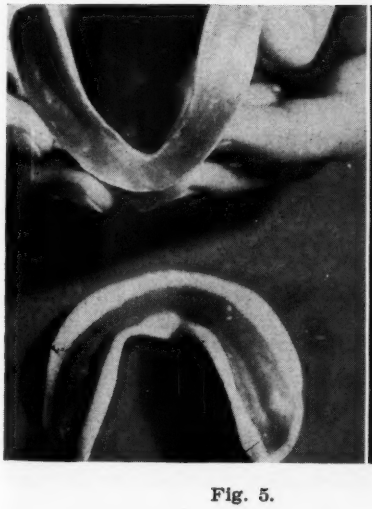

Fig. 5.

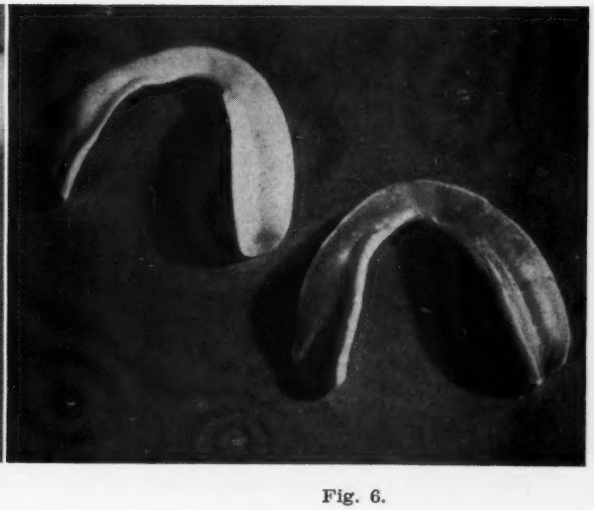

Fig. 6.

After twenty minutes (which allows for setting time of the acrylic), the acrylic tray is removed from the cast and trimmed to the outline of the wax shim (Fig. 5). At this time, a compound handle can be constructed for the tray.

This individual acrylic tray, with the wax shim attached, is tested in the mouth for 2 to 3 mm. underextension. When assured that the prescribed underextension exists, the wax shim is removed from the tray (Fig. 6). The reason for retaining the wax shim while trying the tray in the mouth is that the wax is representing the compound that will be added later for the purpose of obtaining an initial

Fig. 7.

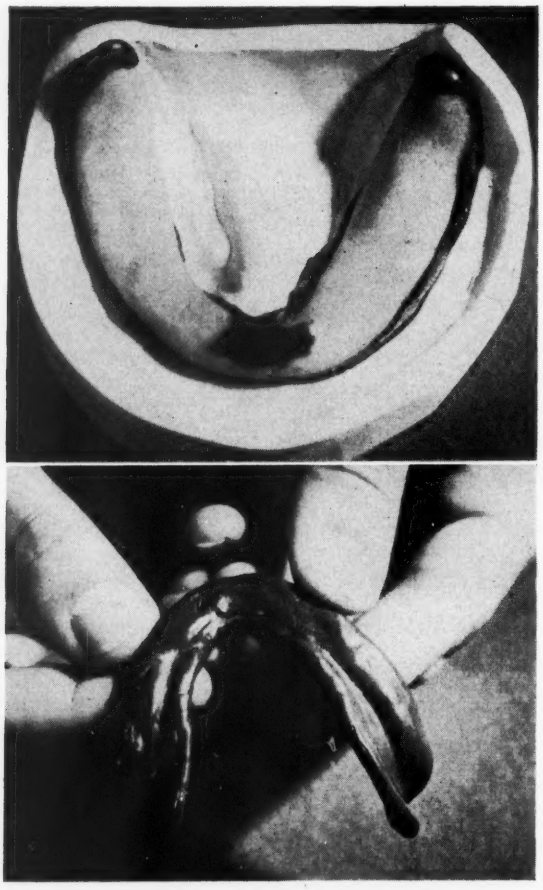

Fig. 8.

impression on the plaster cast (Fig. 7). The reasons for making the initial impression of the residual ridge on the plaster cast are: 1. The tray, filled with soft compound, is much easier to center on the cast than in the patient's mouth. 2. A more even pressure may be applied while centering the tray. This makes for a more uniform thickness of compound which corresponds to the thickness of the wax shim.

This initial compound impression of the residual ridge portion of the cast should be reglazed and seated in the mouth to aid in tissue adaptation.

The tray is then muscle-trimmed with compound, section by section. The buccal portion, from the bicuspid to the distobuccal area, is muscle-trimmed by draping the cheek upward and slightly inward. To provide for maximum denture-bearing area, it is recommended that maximum coverage of the buccal shelf be attained, but only within the limits of tissue tolerance. The buccal shelf provides one of the most valuable denture-supporting areas in cases of this type.

The distobuccal angle is trimmed by having the patient open and close the mouth against pressure exerted by the operator's fingers. This will bring the masseter muscle into action. The distal portion of the impression is trimmed by instructing the patient to open and close the mouth. This area is trimmed by the action of the pterygomandibular raphe. The distolingual or retromylohyoid portion is trimmed by having the patient extend the tongue straight forward. Full extension of the denture borders, within tissue tolerance, is recommended for the lateral throat form area. Maximum extension here will aid materially in the lateral stability of the denture.

The lingual flange section which extends from the distolingual angle to the lingual of the bicuspid region is trimmed by having the patient press the tongue into the opposite cheek or corner of the mouth.

The sublingual gland area should be considered one of the critical areas as an aid in denture retention for this technique. The basic principle is to cover as much of the gland area as possible, yet to be short of interference with the normal function of the gland. Care must be taken not to interfere with the normal flow of saliva. This area is trimmed by having the patient first wet the lips from corner-to-corner with the tip of the tongue; the compound is chilled, then reheated just in the midline, reinserted, and the patient instructed to extend the tongue for the purpose of freeing the lingual frenum. When the genial tubercles are in evidence, it is suggested that they be covered rather than terminating the denture anteriorly to them. Clinical experience has proved that soreness in this area is less likely to develop if this is accomplished.

The labial section from bicuspid to bicuspid region is trimmed by draping the lip upward and slightly inward. The same procedure for all sections is carried out on the opposite side.

The finished compound impression (Fig. 8) is then carried to the mouth and tested for the proper extension. Proper extension is interpreted as being muscle-trimmed to the border tissues, yet not interfering with their normal movements or functions. The compound on the residual ridge portion of this impression is then removed, leaving the muscle-trimmed border intact (Fig. 9). The purpose of its removal is to allow space for the final wash impression material.

A series of escape holes is then made with a No. 8 or 9 bur (Fig. 10). This will allow trapped air and/or impression material to escape during the making of the final impression.

To insure a reduction of saliva, the patient is instructed to rinse the mouth several times with a solution of a few drops of aromatic spirits of ammonia in a glass of water. After this, the mouth is packed with gauze sponges.

The material chosen for the final impression must be as soft as, or softer than, the delicate folds of tissue it is to record to insure a minimum displacement. One recommended material is a zinc oxide-eugenol paste. The paste is thoroughly mixed and placed in the tray. The gauze packs are removed, and the tray is inserted with minimum pressure. It must be stressed that the impression tray is guided to position rather than forced into place. In order to aid in the insertion of the tray, the patient is instructed to touch the roof of the mouth with the tip of the tongue upon its initial insertion. This will allow for better centering and eliminate the possibility of tongue interference. When it is properly centered, the patient is instructed to lower the tongue and rest its tip on the handle of the tray. This will help eliminate tongue gymnastics which could easily displace the tray with its soft wash matrial. Only enough finger pressure is maintained to insure the proper position of the impression tray. No muscle trimming is done at this time, for the original muscle-trimmed border has been preserved.

Fig. 9.

Fig. 10.

If, upon removal and examination of the impression, it is found that the soft tissues of the residual ridge have been registered in their natural relaxed rest position, the impression may be accepted as satisfactory. If imperfections are present, there is only one solution. That is to remove the wash impression material and remake the impression.

The zinc oxide-eugenol impression paste, being extremely soft, will, in many cases, flow beyond the denture periphery, especially in the distolingual portion of the impression. This is easily removed with a knife, and any slight border imperfections resulting can quickly be perfected with a wax which softens at mouth temperature.

The finished impression (Fig. 11) is properly boxed and poured with a thick mix of stone, and the denture is carried to completion in the accepted manner. However, if maximum results are to be attained, a cast metal base should be constructed, for such a base will better reproduce the many delicate folds of soft tissue than will acrylic. The exact reproduction of the ridge tissue is most important to the patient not only for comfort, but also because it will provide for maximum

tissue and denture base adaptation; this will allow for more perfect adhesion by contact. This principle of adhesion and cohesion is of the utmost importance in this technique. Therefore it is recommended that the stone cast (Fig. 12) be duplicated in a refractory investment, and the duplicate cast be waxed up with a 26 gauge wax which will cover all the denture-bearing area except approximately 3 mm. around the entire periphery. This 3 mm. border will be completed in acrylic in the finished denture, and will facilitate peripheral adjustment, if necessary. Retaining loops of 20 gauge round wax are provided for rentention of the acrylic base material (Fig. 13).

Fig. 11.

Fig. 12.

The waxed-up refractory investment cast is invested, and the casting is made in either a chrome or gold alloy. Fig. 14 shows a gold alloy casting. There are two disadvantages to a cast metal base: (1) its cost to the patient, and (2) the difficulty of relining it. However, it is felt that in this technique its advantages far outweigh those of acrylic.

The casting is placed on the original stone cast, and the wax occlusion rim is constructed over this casting, and the denture is carried to completion in the routine manner.

SUMMARY

An analysis of the finished impression is made to see if the four fundamental requirements of an acceptable impression have been met.

1. *Areal Coverage.*—All the denture-bearing area possible within the limits of tissue tolerance has been covered, not the residual ridge alone, but the most important aeras of the buccal shelf and retromolar pad as well.

Fig. 13.

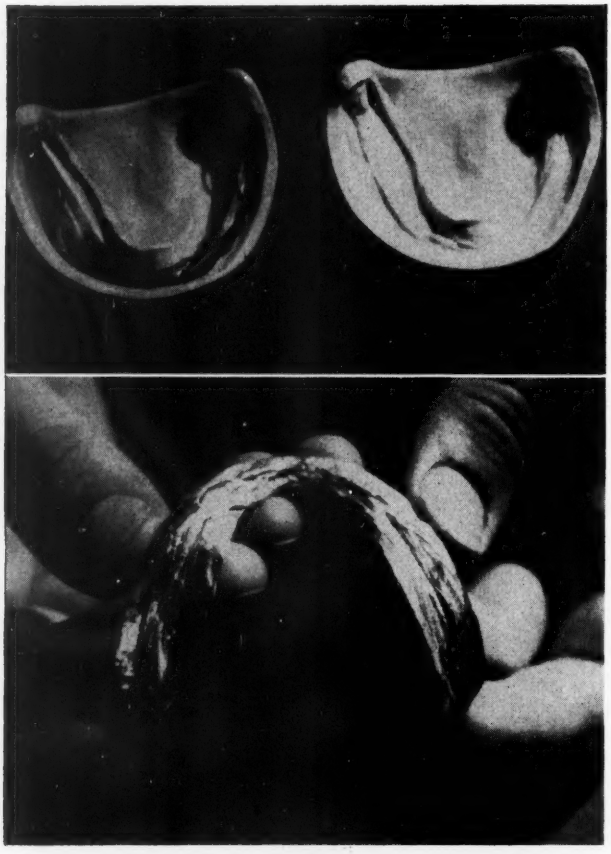

Fig. 14.

2. *Periphery.*—A compound peripheral border has been meticulously established, section by section, within the limits of tissue tolerance.

3. *Valve Seal Without Interference With Functional Movements.*—By establishing a periphery which harmonizes with the anatomic and physiologic landmarks surrounding the denture, provision has been made not only for valve seal, but also for maximum lateral stability.

4. *Accurate Adaptation to the Tissues Without Injurious Displacement.*—A carefully muscle-trimmed periphery insures contact with, but nonimpingement on the border tissues. A final wash material, as soft as, or softer than, the tissues being registered, provides for accurate adaptation without injurious displacement and for equitable distribution of stress. This, plus the fact that a cast metal base is used, further insures that the soft tissues will be more accurately reproduced in the finished denture, with better tissue and denture base adaptation resulting.

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SURGICAL CORRECTIONS FOR THE LOWER EDENTULOUS RIDGE

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THE SHARP AND UNEVEN alveolar process and the knifelike ridges of the mandible are a constant source of pain and discomfort to the patient who wears a lower denture. To construct a satisfactory lower denture, these obstacles must be removed, as they cause undue pressures and discomfort to the wearer.[1] It is very important to be able to diagnose these anatomic interferences and to know the anatomy and composition of the mandible before constructing a lower denture.

The mandible is the largest and strongest bone of the face and serves for the reception of the lower teeth.[2] When these teeth are removed, sixteen cavities remain. These vary in depth and size according to the teeth which they contained, and, also, to the amount of destruction of bone caused by disease, trauma, or surgical removal.

The portion of bone situated on the superior border of the mandible is the alveolar process and is composed of a relatively soft cancellous bone, while the mandible proper is composed of hard compact bone. During the formation of teeth, the alveolar process also forms, and, with the removal of teeth, the process is slowly absorbed. Bone resorption may be the result of an excess in the resorption by the osteoclasts over that of the deposition of bone by the osteoblasts. Resorption in the aged mandible may be brought about by a reduced osteoblastic formation with a normal rate of osteoclastic activity. Resorption may also be due to a loss or lack of lime salts (calcium) in the bone.

It is a fact that the sixteen cavities remaining after the removal of the dentition may refill by the regeneration of bone. However, some of the sockets may fill in with normal resorption taking place, while others fill in with very little resorption. This causes all sorts of anatomic anomalies, such as, knife-edge ridges, protuberances, and sections of sharp and bumpy alveolar bone.

These conditions of the alveolar process are often due to the removal of teeth at different periods of time, resulting in marked irregularities in the outline of the alveolar ridges. The loss of opposing teeth may cause extrusion of the teeth with the comparative growth of the alveolar process, resulting in irregularities of the ridges. Undue trauma and surgical laceration in the removal of teeth will also cause irregularities in bony contour.

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To construct a successful lower denture, ragged and sharp ridges must be corrected surgically by removing the alveolar process, or portions of it, and making the ridges smooth.

Surgical corrections or "alveolectomy" (complete or partial) of the mandible should not be done in "green mouths." This term refers to patients who have had recent full-mouth extractions or any extractions immediately prior to the placing of immediate dentures. Since the alveolectomy operation has been abused or injudiciously performed, many prosthodontists feel the lower alveolar ridge is so flattened and mutilated that it is difficult to make a successful lower denture after it has been done. The operation should only be done for patients when it is definitely indicated. It is better to do it one year or two after all the teeth have been removed and complete healing and resorption have taken place.

Where immediate dentures are to be inserted, it is felt that alveolectomy is not necessary when only the six anterior teeth remain. By careful removal of these teeth with the minimum of trauma and laceration, the denture may be placed. The denture, acting as a splint, will aid in the healing and regeneration of the alveolar ridges, making them firmer and harder. The resulting trauma will be much less than with the alveolectomy, and the healing will be more rapid. Less resorption of the ridges will take place and a better ridge will result. In cases of high or abnormally large and prominent mandibular ridges, or where there is a short lip, the teeth of the immediate denture may be butted against the sockets from which the teeth were removed, omitting the labial portion of the denture. In cases where the labial portion is used, short-bite porcelain or acrylic teeth may be used and lapped labially over the ridge for a more esthetic result. This will eliminate the destructive resorptive results of surgical alveolectomy.

Generally, the surgical correction of the mandibular ridge is indicated only in the edentulous ridge where the teeth have been removed for a period of from one to two or more years. In most patients who have difficulty with lower dentures, we find they have been edentulous for years, or they are in the aged group. Surgical correction of the lower edentulous ridge is indicated after healing and resorption have taken place in those cases where the alveolar process is rough with spicules under the tissues along the ridge, or where sharp labial or buccal undercuts occur. Bony excrescences should also be trimmed.

When the alveolar process is to be removed, it should be trimmed down to the dense, hard, compact bone of the mandible. By waiting a sufficient time for the resorption and healing to take place after the alveolectomy is done, future resorption will be negligible.

The question is asked, "What is the procedure after recent extractions or after seating immediate dentures when three or four sharp points are found remaining a short time later?" These may be removed easily, but if an alveolectomy or surgical correction is done and too much ridge is removed, serious difficulties will be encountered when future dentures are constructed.

Only in edentulous mouths of long standing do we find knife-edge ridges which interfere with the wearing of dentures. These sharp ridges should also

be trimmed down to the hard, compact portion of the lower jaw by complete removal of the alveolar portion of the mandible.

SUMMARY

Surgical correction of the lower edentulous ridge is contraindicated in cases of recent extraction "green mouths," even when placing immediate dentures. When there are a few sharp spines or points remaining three or four weeks after extractions, they may be removed easily without an alveolectomy.

Surgical correction of the lower edentulous ridge should be done when necessary only after the teeth have been removed from one to two years, and after normal healing and resorption have taken place. Where surgical correction is indicated, the alveolar process should be trimmed completely down to the dense, hard, compact bone of the mandible.

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THE ROENTGENOGRAM AS AN AID IN VENEER CROWN PREPARATION

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THE VALUE OF THE roentgenogram in dentistry is beyond calculation. Accurate diagnosis cannot properly be achieved without careful study of well made intraoral roentgenograms in conjunction with other diagnostic procedures. Although the uses of the dental roentgenograms are many and varied, there are perhaps some additional uses which may yet become common practice.

One such use is to employ it as an aid in veneer crown preparations, either full or partial. With the renaissance of fixed bridge prosthesis, more and more teeth are being prepared as abutments. No matter how intimate the knowledge of pulpal anatomy, there is frequently a doubt as to how close the pulp is being approached during tooth preparation. The margin of safety is not always clear. Full-mouth restorative procedures are condemned by many because of the large number of pulpal involvements, either during or following operative procedures. It is true that much of this occurs because of careless operation. Even the most meticulous operator, however, has occasional difficulties. There is most certainly no panacea to completely eliminate exposing or damaging the pulp, but sound judgment and careful procedures will minimize this difficulty.

The roentgen ray can be of value by taking several intraoral roentgenograms of the tooth *during* the process of its preparation. Sometimes one film is sufficient, occasionally two or three may be advisable. Whenever there is doubt as to the position of the pulp, a roentgenogram will, in a matter of minutes, guide the operator and allow him to progress with more swiftness and sureness. The man with much clinical experience will surely need much less guidance than the neophyte, but even he may benefit by this simple procedure.

In addition to minimizing pulpal damage, it is likely that better tooth preparations will result as well. Frequently, a tooth might be better prepared except for the fact that the operator is fearful of encroaching upon the pulp. The roentgenogram will show many times that there is much more tooth structure present than was thought, and allow further and more perfect preparation with confidence and safety.

Further, a good esthetic result is more easily achieved, particularly with the gold and plastic veneer which is in such widespread use. While the roentgenogram will not show the buccolingual position of the pulp, it will clearly

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show its occlusal and proximal position. Determination of the occlusal position after the preparation has been tentatively completed, will often permit further occlusobuccal reduction, allowing for a greater bulk of plastic on the finished veneer.

A few of the instances where radiographs are of especial value are: in the preparation of the mesial surface of the lower molars which are tilted forward; in any abutments which are widely divergent; in any preparation where the pulp is large or has extensive horns; in occlusal reductions, especially when the tooth is elongated beyond the line of occlusion; in the placement of boxes for internal attachments or precision rests; in the placement of pits or grooves for the partial veneer; in the preparation of badly abraded teeth, etc.

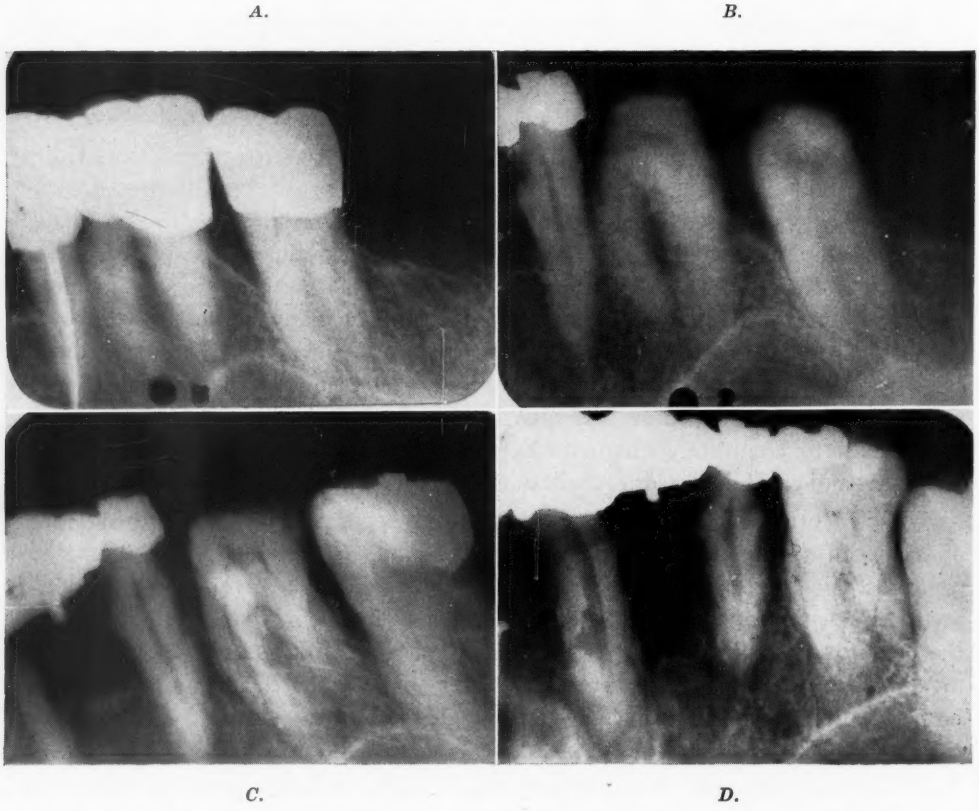

Fig. 1.—*A*, Radiograph prior to preparation. *B*, First molar tentatively prepared. *C*, First and second molars completely prepared. *D*, Castings in position.

The question arises as to the possibility of excessive radiation for both patient and operator. For the operator who must continually be on guard, normal routine precautions are sufficient. Ennis[1] states, "The erythema dose of the roentgen-ray at a target-plate distance of 10 inches may be said to be 1200 milliampere-seconds. By multiplying the number of milliamperes used by the time of exposure in seconds we obtain the exposure-time in milliampere-seconds. The

result is then divided into twelve hundred milliampere-seconds which will give us the number of exposures we may make." It can be seen that sixty films exposed at two seconds each could be taken before reaching the erythema dose, and that even in full-mouth reconstruction not enough exposure is necessary to jeopardize the patient in any way. However, it is imperative that during the taking of the patient's history, information as to previous therapeutic radiation should always be obtained. If the patient has been subjected to any extent to the roentgen ray prior to dental procedures, due consideration must be taken of this fact.

TECHNIQUE

The technique is simple and rapid. Extrafast film is used, and slightly overexposed in order to reduce the developing time. The exposure will vary from one-half of a second to a maximum of two seconds. Since speed is essential, this will vary with the age and temperature of the developing solutions, the exact type of film used, target distance, and the thickness of the tooth. The radiographic technique can be adjusted so that sixty seconds will be sufficient for development so a film of satisfactory quality may be obtained. If desired, an extrafast developer (Collitt) can be kept in a separate container which will permit good development in fifteen seconds.

The film is placed in the mouth in the usual manner, or a "bite-wing" film may be used. In all instances, the central ray is directed at the center of the coronal portion of the tooth, with the angle perpendicular to a line bisecting the mean plane of the crown and the plane of the film where it rests against the crown. Some form of film holder may be used if the operator wishes to take several films with exactly the same angulation. Experience will soon bring about the development of an efficient technique (Fig. 1).

CONCLUSIONS

If the routine practice of making roentgenograms of teeth during their various stages of preparation is carried out, the operator will be well rewarded. He will work with more ease and confidence, in the long run complete a preparation more technically perfect in a shorter period of time, minimize pulpal irritation and damage, and produce restorations of a higher standard esthetically and functionally.

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RATIONALE AND TECHNIQUE OF BIOMECHANICAL OCCLUSAL REHABILITATION

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IN THE FIELD of mouth rehabilitation, there has been a tendency to both an oversimplification of the problems involved and an overcomplication and elaboration of them which seems out of all proportion to the gain secured, if any. Procedure has become either empirical or overly scientific. Hypotheses are presented as fact, and assumptions are rationalized with half-truths.

Nevertheless, success is claimed by all the various schools of thought. May not their results be a product of their skill rather than a proof of their rationale? Technique and philosophy are interdependent, but a good technique does not necessarily justify the philosophy, nor should a philosophy or rationale be discredited because of poor technique. A man may build a house that is a marvel of construction, but it may not meet the living needs of his family, and, conversely, the house may meet the living needs of his family but be structurally unsound. Success is a relative term and must be gauged not by the immediate result alone, but by clinical re-evaluation over a span of years. The final judgment of success must be in terms of how well and for how long the remaining teeth and the supporting structures are preserved.

In this article we shall examine some of the controversial concepts[1] in the light of the knowledge of the day. A rationale predicated upon sound principles together with a technique which over a period of years has given most satisfactory and gratifying results will be presented.

NORMAL OCCLUSION

Normal occlusion is defined by Strang[2] as: "That structural composite consisting fundamentally of the teeth and jaws and characterized by a normal relationship of the so-called occlusal inclined planes of teeth that are individually and collectively located in architectural harmony with their basal bones and with cranial anatomy, exhibit correct proximal contacting and axial positioning and have associated with them a normal growth, development, location, and correlation of all environmental tissues and parts."

The establishment of a concept of normal occlusion is essential to serve as a criterion in detecting and measuring the variations in occlusal relationships in individuals. However, it is important to recognize that an individual occlusion may differ from this concept of normal occlusion and still be normal. The *ultimate standard of normal is functional adequacy* for the particular individual.

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Fox[3] states: "In the absence of clinical and x-ray findings, you cannot predict a pathologic occlusion." The resistance and physiologic health of the patient which he terms "adaptive capacity" may be adequate to accept an occlusal relationship which presents marked deviations from the 'normal' without evidencing destructive changes in the periodontium.

ORAL PHYSIOLOGY

Perhaps the most controversial concept of recent years is that oral physiology demands an anatomic articulation integrated with the mandibular movements. It is necessary to bear in mind that the mandibular movements are of two types: (1) the chewing movements, and (2) the gliding (empty) movements.

The anatomic school of thought maintains that the basis of oral physiology is how the mouth *chews*. Its proponents then proceed to record the *gliding* movements of the mandible claiming that only anatomic teeth articulated to conform to these gliding movements meet the demand of oral physiology, that is, chewing function.

The work of Hildebrand[4] and of Kurth has definitely established that the actual chewing strokes of the patient are diametrically opposite to similar movements of the articulator when viewed in the horizontal and sagittal planes. Kurth[5] states: "The only equivalent movements of the articulator and the patient are in the direction of the free movements or glide. These are not identical but occur in virtually the same direction. This is true irrespective of the type of tooth or occlusion used. The adjustable articulator has absolutely no value in movement, but if properly used, can be helpful in maintaining positional relations obtained direct from the patient. Neither the form of the posterior teeth nor the type of occlusion has any affect on function in the mouth."

Sicher[6] states: "We must remember that the masticatory movements are automatic movements which occur under considerable force and under some contact of the two rows of teeth. Though following a general pattern which could be termed the human pattern of mastication, the masticatory movements vary in details in different individuals. They are dependent on the shape and proportions of the jaws and the mandibular articulation and, to a high degree, upon the shape and position of the teeth. Once established as an automatic series of movements, their pattern is maintained quite persistently. However, loss of teeth, changes in their position or anatomy are followed by a rather rapid adaptation of the neuromuscular pattern in order to achieve maximum effect with minimum effort."

The continually mounting evidence indicates that the anatomic tooth is not a requisite for masticatory function.

PHYSIOLOGIC OCCLUSION OR OPTIMUM OCCLUSION?

Since oral physiology is not dependent on a specific type of occlusion and since the articulator does not duplicate chewing movements, the premise that a physiologic occlusion demands an anatomic articulation geared to the gliding movements of the jaw is open to question.

What then is a physiologic occlusion?

"A physiologic occlusion is one in which the relation between the teeth and the periodontal tissues is such that under occlusal stress no injury is produced by them and further, the tissues are best able to withstand the forces of occlusion without the initiation of pathologic changes in the periodontium." (Box.)[7]

All teeth are subject to both vertical and horizontal stress. The steeper the cusp, the greater the horizontal loading. Vertical loading distributes the stress over the entire alveolus and may be increased considerably without overloading. Horizontal loading acts on the periodontal membrane and bone regionally and frequently exceeds the normal limits of the tissues. (Box.)

Glickman[8] states that the height of alveolar bone is maintained by a physiologic equilibrium between bone formation and bone resorption. Both *local* and *systemic* factors regulate this physiologic equilibrium. The bone-resorptive and bone-formative activity which occurs in response to *functional forces* or inflammation induced by *local irritation* is constantly subject to a systemic regulatory influence. This systemic regulatory influence upon the response of the alveolar bone has been termed by Glickman the "bone factor" in periodontal disease.

In the presence of a positive bone factor, even the existence of occlusal disharmonies will not evidence alveolar bone loss, and conversely, in the presence of a negative bone factor a "normal occlusion" may still demonstrate bone destruction.

Thus before determining what are the morphologic and physical requirements of a physiologic occlusion, it is significant to note that a so-called physiologic occlusion, in the presence of unfavorable systemic influence, may still prove pathogenic to the periodontium. To obviate this seeming contradiction and to lessen the confusion created by this much-abused term, I suggest the term optimum occlusion. *Definition:* Optimum occlusion is one in which the relation between the teeth and the periodontal tissues is such that under occlusal stress the most favorable loading is achieved, thereby fostering the biologic maintenance of the periodontium.

BILATERAL BALANCE VERSUS OPTIMUM LOADING

The question of bilateral balance in the natural dentition is still a controversial one. Those who are opposed argue that mastication is a unilateral process, that bilateral balance rarely occurs in nature, that many healthy dentitions present without bilateral balance and clinch their argument with the pithy comment of Prime, "Enter bolus, exit balance."

Jankelson's[9] recent work promises to resolve this hitherto academic question. He concludes, "The evidence strongly suggests that centric occlusion is the only tooth contact of any significance that occurs during stomatognathic function. Evidence of eccentric tooth balance during eating was not found. There was no evidence that balance of teeth in eccentric positions is a physiologic necessity, or that lack of eccentric balance is less conductive to masticatory function."

Although bilateral balance is not essential to masticatory function, it is a most desirable adjunct to occlusal reconstructions. Here we are dealing with

mutilated dentitions and periodontal breakdown, and bilateral balance serves to distribute the occlusal loading over more teeth and greater saddle area. This distribution of loading is probably more important during the nonchewing movements than in actual mastication. We know that actual chewing function occupies but one hour a day, and we have also learned from the work of Hildebrand, Jankelson, and others, that even in chewing, teeth make only occasional contact. However, in the twenty-three remaining hours of the day, the teeth contact innumerable times: in swallowing, during conversation, and in tensional movements. How many of our patients requiring occlusal reconstruction are completely free of emotional tension which frequently is attended by clenching, tapping, or gritting of the teeth, although perhaps unconsciously? It is during these twenty-three hours of nonchewing and tensional contacts that the teeth are subjected to repeated stress, and it is during this time that bilateral balance serves to mitigate that stress by wider distribution of it.

Thus bilateral balance is essential to achieving optimum loading of our reconstructed occlusion. (Note: Bilateral balance, as it is used here, imples contact of all the posterior teeth and not a single balancing point or area.)

THE OPTIMUM OCCLUSAL PATTERN

From the preceding it would follow that the optimum occlusal pattern for rehabilitation is the most shallow intercuspation consistent with bilateral balance.

What can we do to influence and achieve such an occlusal pattern? In virtually every reconstruction case, we find it necessary to re-establish correct centric relation and/or to restore lost vertical dimension. Both of these changes cause the mandible to be brought downward, decreasing the vertical overlap. This results in a decrease in the degree of inclination of the incisal guidance. Judicious grinding and reshaping of the anterior teeth, or rebuilding the anterior teeth can achieve further reduction in the angle of the incisal inclination. Let us now see how by control of this single factor (the angle of the incisal guidance) we can drastically influence cusp height. Fig. 1 illustrates a comparative study of two different incisal guide angles with the same condyle angle. In Fig. 1,*A* (with a 50 degree incisal guide angle) we find that in order to achieve occlusal harmony, we must build upper lingual cusps (and, conversely, lower buccal cusps) ranging from 32.5 to 41 degrees, and also we must build upper buccal cusps (and, conversely, lower lingual cusps) ranging from 15.5 to 32.5 degrees. In Fig. 1,*B* with a 0 degree incisal guidance and the same condylar inclination, we find that we need only build upper lingual cusps (and conversely, lower buccal cusps) ranging from 17.5 to 9 degrees, and also that all the upper buccal cusps and all the lower lingual cusps require a 0 degree inclination.

Fig. 1,*A* is representative of an anatomic articulation. In Fig. 1,*B*, there is no interdigitation of cusps, and in gliding from the centric position forward, the teeth encounter a free path without cusp inclines. Fig. 1,*B* is representative of a biomechanic occlusion.

Let us trace these lateral gliding movements in the mouth starting from centric occlusion and ending in left lateral occlusion as illustrated in the schematic drawing.

In Fig. 1,*A'* (no Bennett movement present),[10] the working condyle lying in the mandibular fossa begins to pivot or rotate horizontally (on its vertical axis). However, due to the upper buccal cusp inclines on the working side, the condyle is now compelled to rotate on its horizontal axis, dropping the body of the mandible vertically, and allowing the lower buccal cusps to glide down along the upper buccal inclines and assume their cusp-to-cusp relationship. The balancing condyle glides down along the posterior slope of the articular tubercle, and comes to

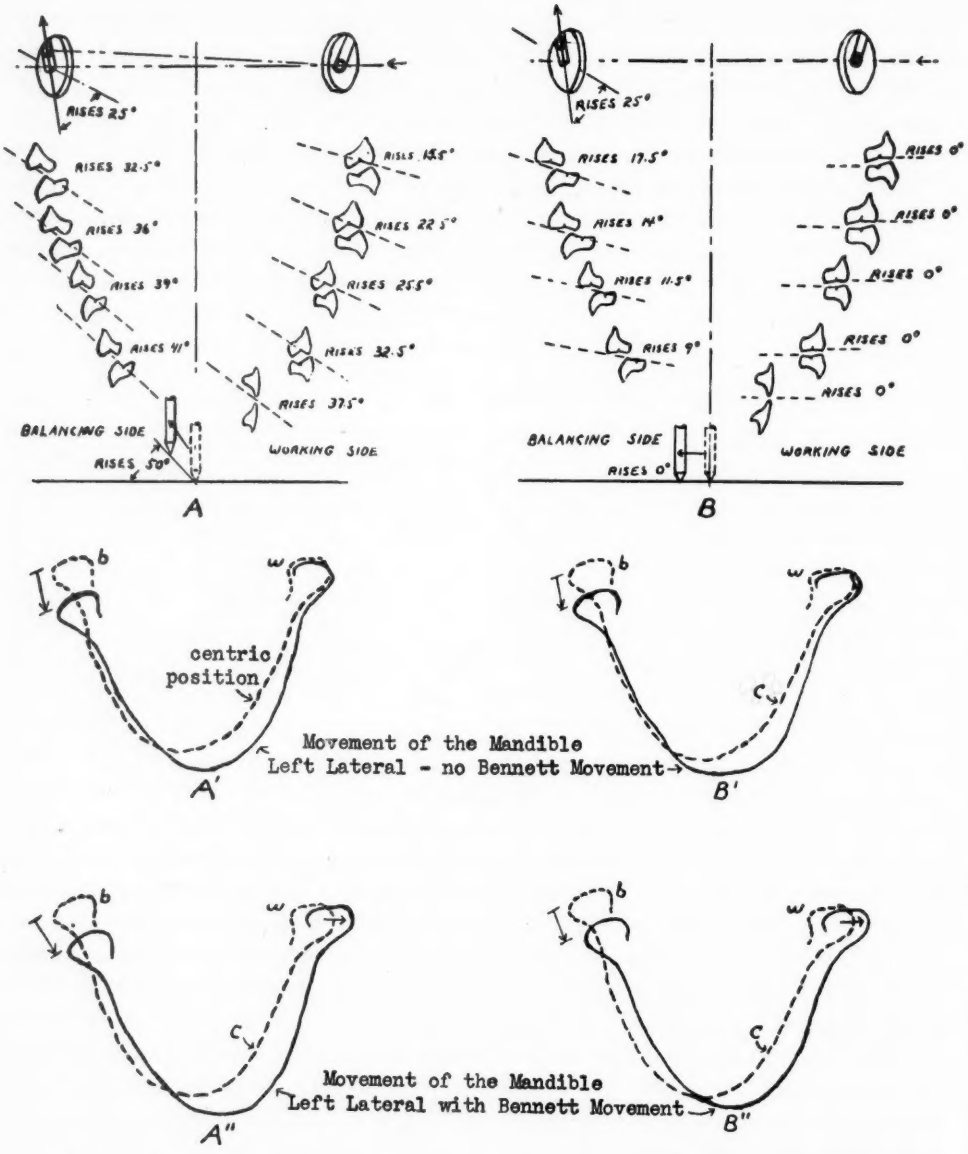

Fig. 1.—*A* and *B*, comparative study of the influence of the incisal guidance on the working and balancing sides. (After Swenson.) *A'*, *B' A"* and *B"*, Movement of the Mandible. (After Boucher.[10])

rest when the working side inclines achieve their lateral contacting position. The balancing teeth have no influence on the movement of the balancing condyle except where there is premature contact of these balancing teeth. The balancing condyle in gliding down the articular tubercle drops the mandible lower on the balancing side, and therefore the upper lingual cusps must always be steeper than the upper buccal cusps to achieve bilateral balance.

In Fig. 1,*B'*, the working condyle pivots on its horizontal axis as in Fig. 1,*A*, but does not have to rotate on its horizontal axis to permit the lower buccal cusps to reach their lateral contacting position, because the upper buccal cusp inclines are at zero degrees. The balancing condyle travels as just described but does not have to travel as far down on the articular tubercle to achieve its balancing position.

In Fig. 1,*A"* (Bennett movement present),[10] there is some clearance between the condyle (on the balancing side) and the medial wall of the fossa; as the mandible glides into left lateral position, the pull of the right external pterygoid muscle draws the right (balancing) condyle toward the inner wall of the fossa in the Bennett movement. This carries the mandible and left condyle further laterally than in Fig. 1,*A'* where no Bennett movement is present. This shift in the pivoting center of the mandibular gliding movement does not appreciably affect the cusp *heights* previously established, but does affect materially the curvature of all the cusps (upper and lower, right and left) as they glide by each other to reach their lateral contacting positions. Thus, the cusps in 1,*A'* if used unaltered in Fig. 1,*A"* would prove traumatic to the teeth and the condyles.

In Fig. 1,*B"* the Bennett movement has no influence on the cusp anatomy since there is no interdigitation of cusps anteroposteriorly. The cusps do not follow the identical path as in 1,*B'*, but there is no interference to their movement and no trauma results.

PRACTICAL APPLICATION

In occlusal rehabilitation, we can rarely achieve a zero degree incisal guidance. However, we can almost always achieve a zero degree working guidance. The two end factors controlling the lateral movement are the condylar incline on the balancing side, and the cusp inclines on the working side (Hanau). By creating zero degree upper buccal cusps we automatically establish a zero degree working guidance, which in turn establishes minimum lingual cusps consistent with the existing condylar incline on the balancing side. It is hardly necessary to observe that, where a cuspid or lateral make contact in the lateral working movement, these teeth must be brought into harmony with the posterior working inclines. In the protrusive movement, as many of the anterior teeth are made to contact as possible. (Posterior contact in this position is frequently not present. It must be remembered that where the vertical overlap exceeds 3 mm., protrusive balance is not possible, regardless of the cusp employed.)

It is significant to observe that the occlusal pattern developed with a zero degree working guidance results in a most favorable occlusoaxial relation. The occlusal pitch that is created complements both the buccal inclination of the

upper posterior teeth and the lingual inclination of the lower posterior teeth. The resulting occlusal surface tends to direct the vertical stresses in line with the long axis of the posterior teeth even more successfully than a flat occlusal surface that has no pitch.

THE TOLERANCE FACTOR IN OCCLUSION

In mouth rehabilitation where we are frequently confronted with partial complements of teeth and extensive edentulous areas, consideration of the effect of function is particularly important. Will the reconstructed occlusion remain static? Will not the altered function and the altered occlusal forces (because of the new articulating surfaces) cause a reorganization of the alveolar bone? If there is a reorganization, may not the articulation alter again? Certainly you are all aware of this phenomenon, either consciously or subconsciously, when you recall your patient to check the occlusion subsequent to completion of the restorations. You have experienced this phenomenon when you have found it necessary to touch up or adjust the occlusion many months after the delivery of the restorations. Has there been a slight depression of the teeth? Has there been a slight movement en masse of all the teeth and prosthesis? And how about subsequent wear of the prosthesis?

Where the occlusal surfaces had been reconstructed to an anatomic articulation, the paths of movement are closely bounded by interdigitating cusps. The slightest change due to reorganization or wear may completely disorient the articulation. There is no tolerance in the occlusal relationship of an anatomic articulation; this would be contrary to its very concept. Correction in the mouth would be extremely difficult if not impossible. Mutilation of the original articulation would be inevitable.

With the shallow modified cusp as in Fig. 1,*B*, there is no interdigitation of cusps. A slight change due to reorganization or wear can be easily compensated for by a slight adjustment in the mouth. This tolerance factor is an important and added safeguard to the continued success of the rehabilitation.

DECALOGUE FOR OCCLUSAL REHABILITATION

1. Occlusal rehabilitation is a radical and serious procedure. It should not be undertaken merely because the occlusal relationship existing does not conform to preconceived concepts of the normal or ideal.

2. The ultimate standard of normal is functional adequacy. In the presence of functional adequacy, conservative treatment is indicated.

3. Where pathologic changes in the periodontium are in evidence, and where mutilation and/or occlusal disharmonies are present, mouth rehabilitation is indicated.

4. Where extensive prosthesis is necessary, occlusal reconstruction is indicated although no pathosis is evident. It will enhance the success of the treatment.

5. The final judgment of success must be in terms of how well and for how long the remaining teeth and supporting structures are preserved.

6. There is no evidence that an anatomic articulation is a physiologic necessity. Chewing efficiency can exist over a wide range of occlusal forms and types of occlusion.

7. Bilateral balance, although not essential to masticatory function, is desirable in that it serves to mitigate the stresses of nonchewing and tensional tooth contacts by their wider distribution.

8. The optimum occlusal pattern for occlusal reconstruction is the most shallow cuspation consistent with bilateral balance.

9. A reconstructed occlusion cannot be regarded as static; a tolerance factor to permit simple correction for reorganization and wear is desirable to safeguard the result.

10. Optimum occlusion (where the relation between the teeth and the periodontal tissues is such that under occlusal stress the most favorable loading is achieved thereby fostering the biologic maintenance of the periodontium) is the goal of occlusal rehabilitation.

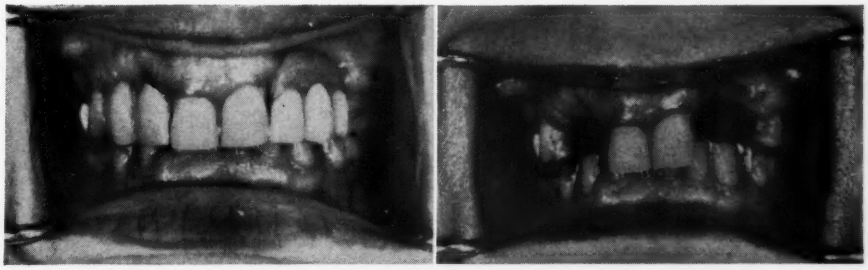

Fig. 2. Fig. 3.

Fig. 2.—Before treatment.
Fig. 3.—Before (with existing prosthesis removed).

CLASSIFICATION AND TECHNIQUE OF TREATMENT

The conditions which require occlusal reconstruction may be classified in three categories:

Class A.—Condyles in normal resting position in the fossae, loss of vertical dimension due to missing teeth, drifting of teeth or abnormal wear of teeth.

Class B.—Condyles in inferior and anterior (mesial) relation in the fossae, mutilation of the teeth, loss of vertical dimension or increase of vertical dimension due to eccentric contact.

Class C.—Condyles in superior and posterior (distal) relation in fossae with loss of vertical dimension.

The technique of treatment is very much the same for all three classes. To illustrate the technique, the complete treatment of a patient will be described.

CASE REPORT

Mrs. S. had a history of constant dental treatment and an inability to chew fibrous meats. She believed that early loss of all her teeth was inevitable and was embarrassed at the appearance of her teeth; this resulted in a tight-lipped, constrained smile (Figs. 2 and 3).

Step 1.—Roentgenograms and study casts were made. The study casts were poured in duplicate (Fig. 4). The physiologic rest position was determined, and the free-way space was measured and recorded; the free-way space was found to be 7 mm.

Step 2.—The upper cast was mounted on a Hanau Model H articulator by means of a face-bow.

Step 3.—Centric relation was recorded with a wax registration. Either Aluwax or several layers of baseplate wax may be used in the procedure; the teeth must not perforate the wax in this registration.

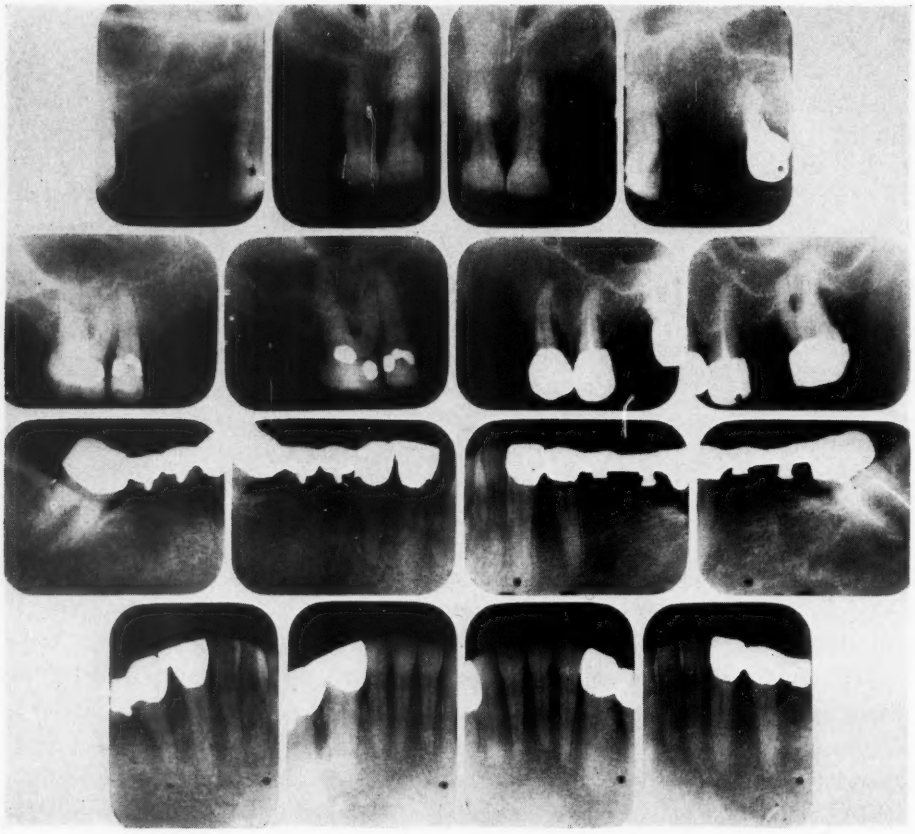

Fig. 4.—Roentgenograms (before).

Step 4.—The lower cast was mounted by means of this wax registration.

Step 5.—With the aid of the correctly mounted study casts, the roentgenograms, and the clinical examination, the treatment was planned. Because of the rather poor bone structure, it was decided to increase the vertical dimension only 3 mm. A gingivectomy over the upper central incisors to create a more harmonious neckline and a compensatory reduction incisally to reproduce the original clinical crown length were planned. The upper anterior segment, from right second bicuspid to left first molar, was to be restored with a fixed splint. The upper right first and second molars and upper left second molar were to be restored with a precision partial denture. Because of some mobility of the abutment

teeth, it was decided to restore the lower missing posterior teeth with a precision partial denture and to splint the lower right cuspid and first bicuspid.

Step 6.—The lower teeth were prepared first. For both corrective and preventive reasons, full coverage is indicated in occlusal reconstruction.

Step 7.—Individual copper band compound impressions were made. Where the saliva is watery or where cement or amalgam fillings are present in the finished preparations, Alboline is used as a lubricant to facilitate removal. The copper band is lipped to provide better purchase.

Step 8.—An alginate lower impression and wax centric registration were made.

Step 9.—Copper-plated dies were made and seated in the lower alginate impression. A cast was made and mounted by means of the wax centric registration against the upper study cast (preserved from Step 2).

Step 10.—Individual transfers were waxed up (in casting wax) on the lower dies. Windows were cut out to expose the mesiobuccal corners of the prepared teeth. The transfers were built to a straight plane and to the planned occlusal level and cast in coin silver. These cast silver transfers increased the vertical dimension about 1½ mm., allowing an equal increase for the upper jaw. (This ratio is sometimes altered to favor the jaw with the poorer periodontal structures.)

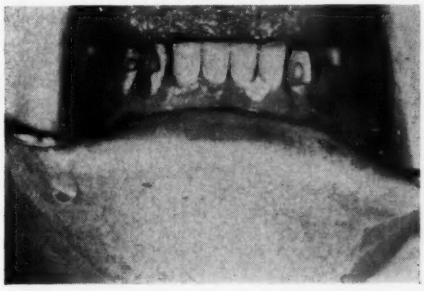

Fig. 5.—Cast silver transfers seated and adjusted to occlusion.

These cast silver transfers serve several important functions. They provide a check for the accuracy of the band impressions and the subsequent permanent castings. They serve as a most accurate seat for the dies in building the temporary splints. They subsequently establish, in conjunction with their upper counterparts, the correct vertical dimension. They accurately establish the correct positional relationship of the teeth, permitting accurate fashioning of the final individual restorations.

The cast silver transfer is very hardy and not readily mutilated, as is a low-fusing metal transfer.

Step 11.—The cast silver transfers were tried in the mouth, and the accurate seating of these castings was checked by means of the buccal window (Fig. 5).

Step 12.—The occlusion was adjusted where necessary, and another centric wax registration was made.

Step 13.—A Truplastic (or plaster) lower impression was made with the transfers in position. Where some natural untreated teeth were present, the undercuts were filled in with a soft wax or Moldine; however, just the occlusal third of these teeth can be engaged, and the impression will remove in one piece with the silver transfers locked in the impression material (Fig. 6).

Step 14.—The dies were now seated in the silver transfers (Fig. 7) and a cast made. This cast was again mounted against the upper study cast on the articulator (preserved from Step 2) by means of the new centric wax registration.

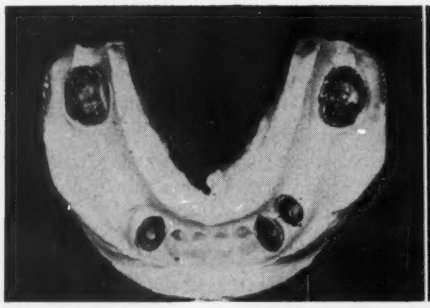

Fig. 6.

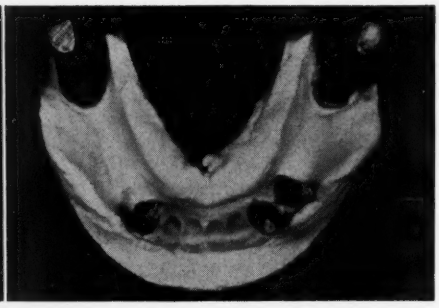

Fig. 7.

Fig. 6.—Transfers locked in Truplastic impression.

Fig. 7.—Copper-plated dies seated in transfers.

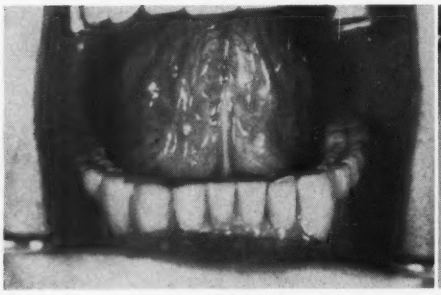

Fig. 8.

Fig. 9.

Fig. 8.—Provisional lower acrylic splints in position.

Fig. 9.—The occlusion is adjusted. Spot-grinding is done largely at expense of the upper teeth.

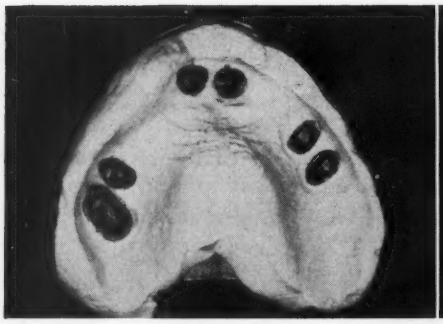

Fig. 10.

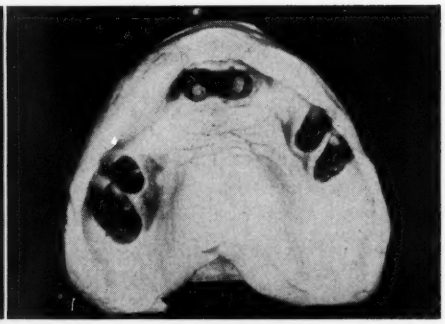

Fig. 11.

Fig. 10—Truplastic impression of upper jaw carrying cast silver transfers which have been built to the desired vertical dimension.

Fig. 11.—Copper-plated dies of prepared upper teeth seated in the transfers.

Step 15.—Provisional lower acrylic splints were constructed, built to a straight plane and to the level established by the lower silver transfers (Fig. 8). (No attempt was made to establish bilateral balance in the provisional splints.)

Step 16.—The provisional lower acrylic splints were cemented in the mouth with Tempak or similar material, and the occlusion was adjusted (Fig. 9).

Step 17.—The upper jaw was treated similarly, and the provisional upper acrylic splints were inserted (Figs. 10, 11, and 12). The provisional splints serve several important functions. They provide a trial check for the new vertical dimension. They permit the patient to become accustomed to the correct centric relation, and to a normal chewing pattern. They guard against oversight and error in procedure. They constitute a preview for the correctness of the mechanics and a guide for the esthetics. They serve as temporary appliances while the final prosthesis is in construction. They hold and stabilize the prepared teeth in their proper relation to each other, thereby guarding against shift.

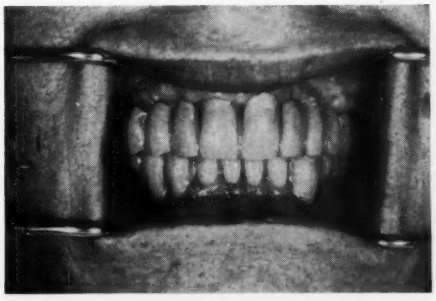

Fig. 12.—Provisional upper acrylic splint in position. A gingivectomy over the central incisors was performed prior to the preparation of these teeth.

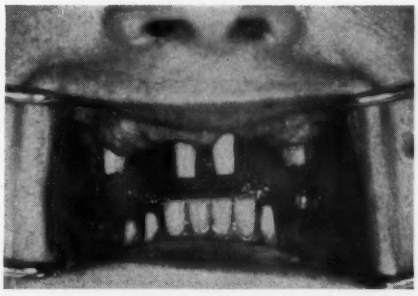

Fig. 13.—Provisional splints removed and the teeth cleansed of cementing media.

Even though the final prosthesis may call for removable partial dentures, the provisional splints should, wherever possible, be fixed.

The provisional splints are indispensible for the neophyte and insurance for the expert.

The patient is permitted to wear these provisional splints for one to two months before the final prosthesis is constructed.

Step 18.—The copper dies and silver transfers are carefully stored for use in constructing the final prosthesis.

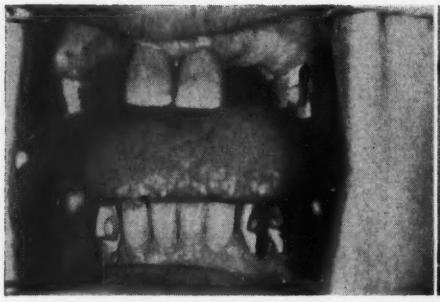

Fig. 14.

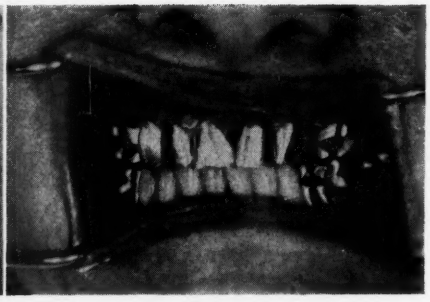

Fig. 15.

Fig. 14.—Upper and lower cast silver transfers seated in the mouth.

Fig. 15.—A similar case demonstrating how the cast silver transfers establish the proper vertical dimension and correct anterior tooth length insuring accurate centric and protrusive records.

Fig. 16.

Fig. 17.

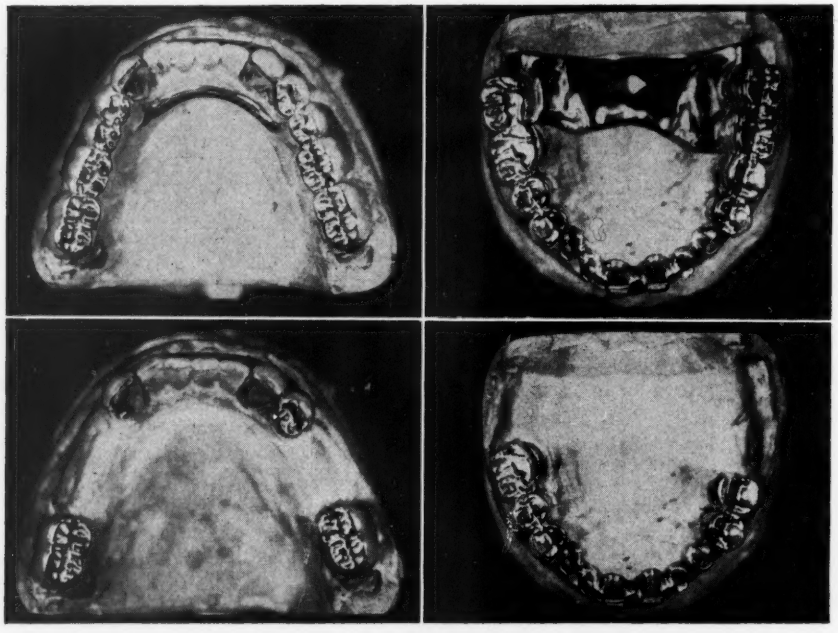

Fig. 18.

Fig. 19.

Fig. 16.—Upper splint.

Fig. 17.—Lower splint and abutments

Fig. 18.—Upper precision partial denture completed.

Fig. 19.—Lower precision partial denture completed.

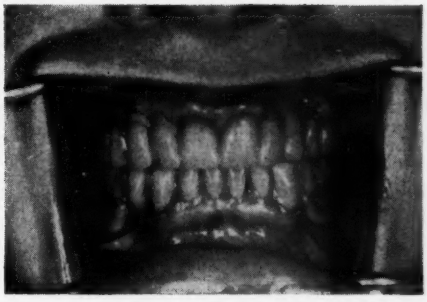

Fig. 20.—The completed restorations.

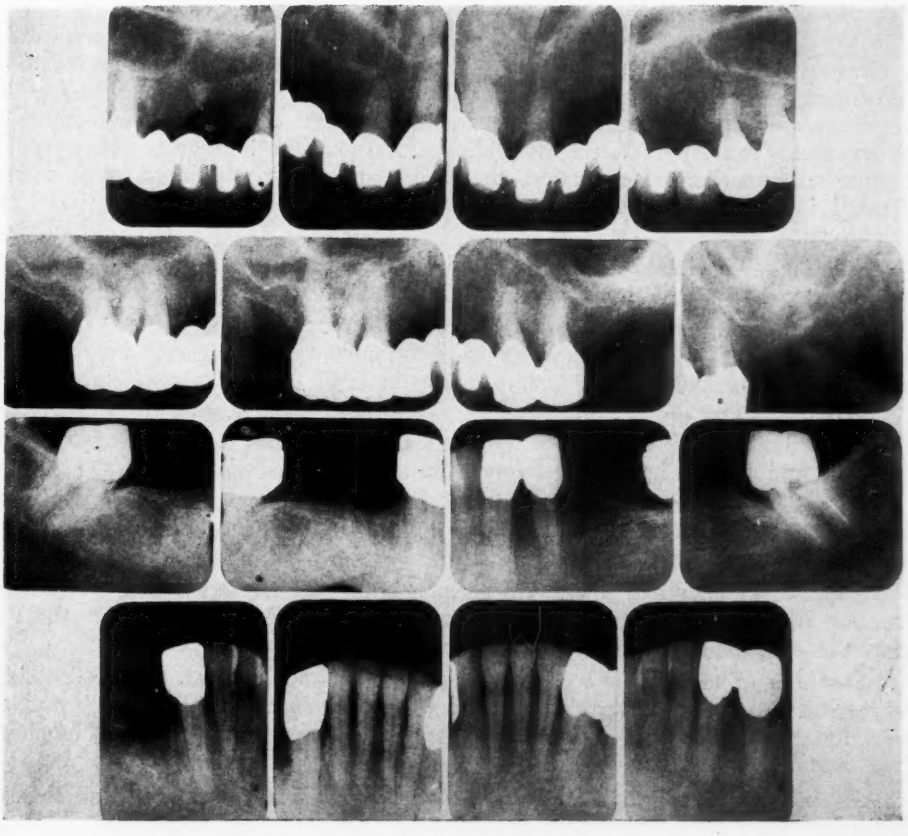

Fig. 21.—Roentgenograms (after treatment).

THE FINAL PROSTHESIS

Where the provisional splints have been carefully executed, the patient will usually experience a feeling of oral comfort and well-being within a few days.. It is, however, recommended that at least one month be allowed to elapse before the construction of the final prosthesis is undertaken.

Step 19.—The provisional splints were removed, and the teeth were cleansed of all cementing media (Fig. 13).

Step 20.—The cast silver transfers previously employed in constructing the upper and lower provisional splints were placed in the mouth. The correct and proved vertical dimension was automatically established for their contact (Figs. 14 and 15).

Step 21.—A face-bow registration was made.

Step 22.—A centric wax registration was made.

Step 23.—A protrusive wax registration was made.

Step 24.—Upper and lower Truplastic (or plaster) impressions were made. The original dies used in constructing the provisional splints were inserted in the silver transfers, and casts were poured.

Step 25.—The upper cast was mounted on a Hanau Model H articulator by means of a face-bow registration. The lower cast was mounted by means of the centric wax registration. The condyle inclinations were set by means of the protrusive wax registration. It is not maintained that the gliding movements on the articulator exactly duplicate the gliding movements in the mouth. However, in building a biomechanical occlusion, the discrepancy is so slight as to be readily adjusted in the mouth without appreciable change or mutilation of the occlusal pattern.

Step 26.—The incisal pin was locked at the vertical dimension established by the silver transfers, and the working condylar guidances were set at zero degrees.

Step 27.—The occlusal pattern was then developed. The occlusal plane was given a slight compensating curve to bring the cuspids more readily into harmony with the working inclines and to improve esthetics.

Step 28.—The upper and lower veneer crowns were waxed up, checked for bilateral balance, and cast. The copings for the upper central incisors were waxed up and cast. The castings were trimmed and polished.

Step 29.—The casting were placed in the mouth and checked again for bilateral balance. The patient should be instructed to execute the gliding movements of the jaw with minimum pressure.

Step 30.—Upper and lower full alginate impressions were made for the construction of cast aluminum impression trays which were to be used for the final impressions of the areas to be restored by removable partial dentures.

Step 31.—The castings were reseated in the mouth, and an upper Truplastic impression was made for the construction of the upper fixed splint. A Truplastic index for splinting the lower right cuspid and first bicuspid was made. The splints were completed (Figs. 16 and 17).

Step 32.—The splints and abutments were seated in the mouth, and the cast aluminum trays were fitted and adjusted.

Step 33.—A zinc oxide-eugenol impression paste was placed in the aluminum tray, and an impression of the edentulous areas was made. The excess impression material was trimmed away, the impression was removed, checked, and replaced in the mouth.

Step 34.—An over-all Truplastic impression was made in a tray in which two or three large holes had been cut. These holes permit the insertion of two or three fingers to exert a firm seating pressure against the aluminum tray while the Truplastic is setting.

Step 35.—Casts were poured and mounted on the articulator. (A new face-bow and centric relation record are sometimes necessary for proper mounting on the articulator.) The precision partial dentures were constructed to conform to the established occlusal pattern (Figs. 18 and 19).

Step 36.—The baking of the upper anterior porcelain jacket crowns completed the reconstruction (Figs. 20 and 21).

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BIO-MECHANICS OF PROSTHETIC DENTISTRY

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IMPORTANT CORRELATIONS exist between biology and mechanics. Health of the dental investing tissues is critically bound to horizontal forces acting upon the periodontium.

While young patients with good periodontal metabolism will tolerate the additional loading to horizontal thrust when bridge prostheses are attached to the remaining teeth and may even experience hypertrophy of the investing tissues as a result of the greater demand, older individuals do not respond as well to the same demand. In most mouths the alveolar process has undergone considerable atrophy and resorption by the fiftieth year and degenerative changes in the periodontium may come much earlier in life. When teeth are lost, deterioration is accelerated. The mechanics of restorative dentistry may place additional burdens, and periodontal damage may be accelerated. This is evident when cantilever bridgework or clasp-type partial dentures are employed in mouths exhibiting periodontosis.

As a result of this study we will see that dental investing tissues have variable capacity to take horizontal load and, further, that it is possible to use dental investing tissues at higher capacity for prosthetic purposes without producing degenerative changes or accelerating the degenerative process. If the investing tissues are intelligently utilized, the life of the remaining teeth will be prolonged. Using investing tissues at maximum capacity has special importance when deterioration of these tissues has occurred either through disease or aging, and when the remaining teeth must still serve as supports or abutments for prosthetic appliances.

A study of the mechanical differences among a fixed and a cantilever bridge and other prostheses may take this form: from the study with the cardboard models,[1, 2] it is surprising to discover that even greatly tipped abutment teeth do not move toward each other, as might be expected, under heavy occlusal loading on the pontic when fixed bridges are used. While it is common practice to employ cantilever construction for bridgework where the abutments tip toward each other in order to facilitate cavity preparation and placement of the prosthesis, from the experiment it would seem that tipped teeth require fixed or rigid coupling of the abutment castings.

A schematic deflection diagram to illustrate the conditions of concentrated vertical loading on a fixed bridge is shown in Fig. 1, *A*. Contraflexure occurs at *X* and *Y*. If the abutment castings hold to the shearing action on the cement, the deflection of the pontic produces a bending or bowing of the abutment teeth.

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Since teeth have considerable stiffness and mass, and since the shortening of the pontic caused by deflection is ordinarily of a low order, the significant force transmitted to the supporting teeth is axial. This tends to stretch the periodontal fibers and these in turn pull upon the alveolar bone to put it in tension. The situation is one approaching that of the bending of a lower molar when concentrated biting force is borne in the central fossa between the two roots of the tooth.

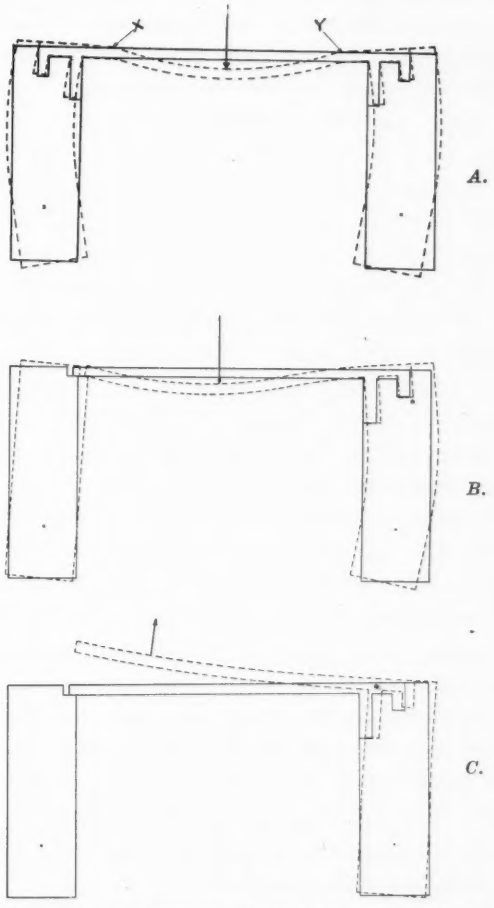


Fig. 1.—*A*, Schematic deflection diagram illustrating the effect of concentrated vertical loading on a fixed bridge. Contraflexure occurs at *X* and *Y*. *B*, Schematic deflection diagram of "stress-broken" or cantilever bridge in "positive" occlusion. *C*, Schematic deflection diagram of cantilever bridge in "negative" occlusion.

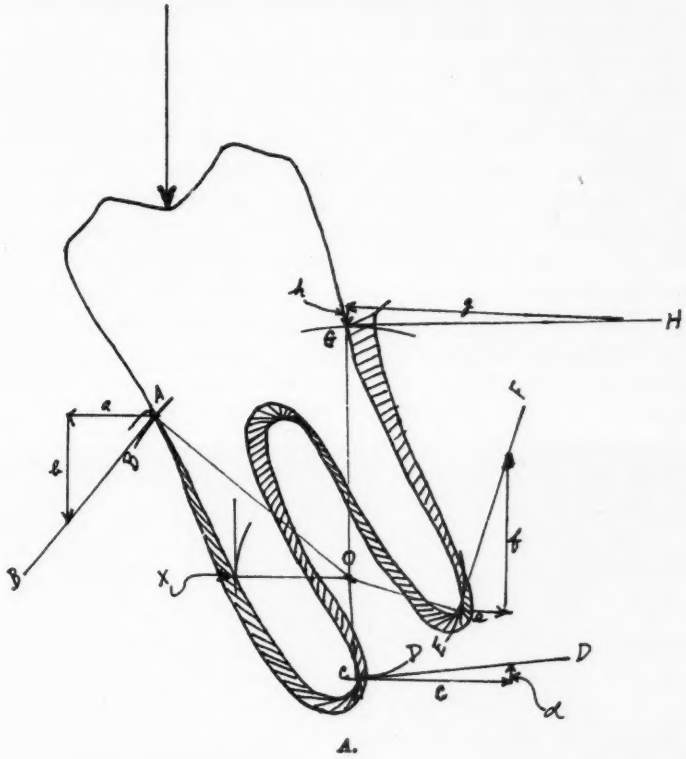
The foundational stability of the cantilever type of construction is not as satisfactory as that of a fully fixed bridge. Usually there is sufficient movement in the lug to permit simple hinge movement of the primary abutment buccolingually to horizontal forces and mesiodistally to vertical forces (Fig. 1, *B* and *C*). The looseness of the lug at the secondary abutment permits this tooth to turn distally on its axis of rotation due to the eccentric loading on the lug. It is

generally recognized that periodontal tissue is injured by excessive compressive force. If the loose coupling permits hinge action, positive and negative vertical loading on the bridge pontic will cause excessive movement at the axis of rotation of the primary abutment. The movement will be progressively greater from the axis occlusalward and in the same order though in a reverse direction from the axis to the apex of the root. Bone resorption will be greatest where the compression of the periodontal membrane is greatest and, of course, this is the clinical picture of the damaged investing tissues associated with cantilever bridges in the mouths of patients susceptible to periodontal disease. Bridgework with rigid couplings is indicated for patients with poor periodontal metabolism.

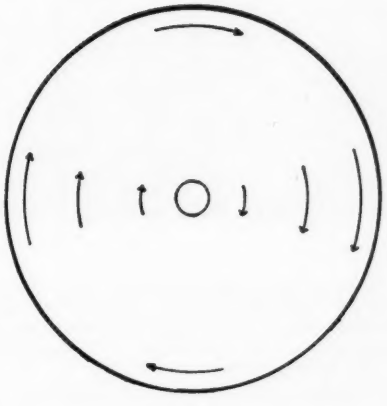
Tipped teeth are weakened as prosthetic supports. Vertical forces on tipped teeth resolve into large horizontal components of force in the root structure. Even centric loading on a tipped tooth is in reality eccentric loading as can be seen in Fig. 2, *A*. Rotation occurs on *O* as center whereas if the tooth were perfectly straight, vertical forces concentrated in the central fossa would be directly over *O*, and rotation would not occur. From Fig. 2, *A* it can be seen that the eccentric load may be resolved into horizontal forces *a, c, e,* and *g*. Line *BA* is the tangent to arc *BA* and is therefore the direction of force acting at *A*. Similarly *CD* is the tangent to arc *CD* and is the direction of force at *C*. It should be observed that the vertical force component at *C* is not down but *up* because point *C* is to the right of center. Only at *X* is vertical loading on the crown of the tooth taken as pure vertical downward loading on the investing tissues. The other tangents and resolutions have been similarly drawn.

If this analysis contains surprises, the reader should not view it as profound. He need only recall that the rotation of a phonograph record exhibits exactly the same conditions. At a given moment, a particle on the right side of the record, (Fig. 2, *B*) is moving from top to bottom. At the same instant a particle at the bottom is moving from right to left. Other particles on the left of the record are moving from bottom to top and still others from left to right. The particles are not only constantly changing their direction of travel, but the velocities of the particles are also not constant, being less as points are taken nearer center. At exact center the particle does not move whether the record turns or stands still. These are properties of all rotations, and our analysis reveals truths not only for rotations of teeth in their sockets but also, as we shall see shortly, for the rotations of the mandible.

"Stress-broken" cantilever construction may restrict the rotational tendency of a tipped primary abutment in positive occlusion, but the cantilever increases the rotational effect in negative occlusion and in certain of the milling movements of chewing which will be discussed later. Tipped abutments exhibit varying degrees of mobility, and the loose coupling of a stress breaker exacerbates local infectious processes by the pumping action incident to use of the bridge. Certainly cantilever construction should never make use of an occlusal or highly tapered lug in a tipped distal abutment because no restraint will be offered to the rotation of this abutment. Shortly after placement of such construction one may expect that the distal abutment will tip or turn out of contact with the base



A.



B.

Fig. 2.—*A*, Resolution of horizontal force components in the root structure of multi-rooted tooth subjected to eccentric loading. *B*, Analysis to show directions and velocities of discrete particles in rotating disc.

of the lug through mesial drift or looseness and most of the cantilever support will be borne by the smaller abutment.

The above is true in the vertical phase of occlusal loading, but in the horizontal phase of loading the effects of masticatory effort ore even more damaging. The following is an experimental and geometric analysis of this dental problem:

A single-rooted tooth, (Fig. 3, *A*) turns on an axis of rotation, *a,* to horizontal force, *b*. Only the periodontal fibers on the tensile one-half of the root from the axis of rotation occlusalward are resisting the push well, because the fibers on the other side are being compressed. Furthermore, the resistance of the tensed fibers becomes progressively less as points are taken closer and closer to the axis of rotation because the displacement of the tooth is proportional to the distance from the axis. The same relations hold on the opposite sides of the root from the

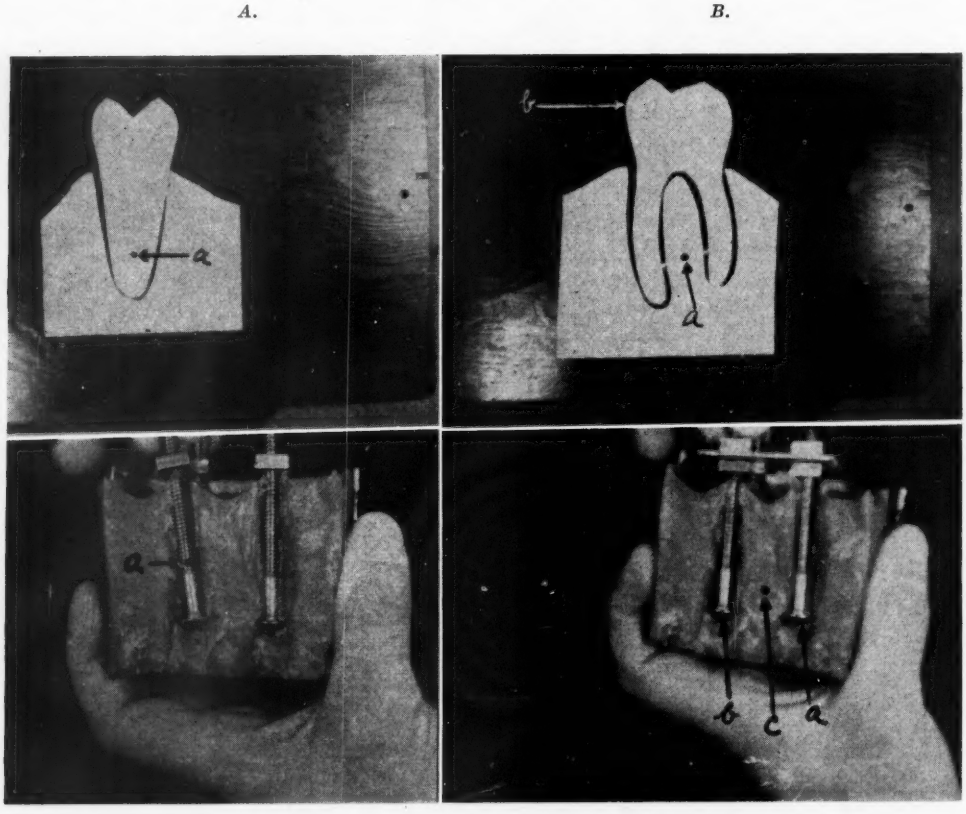


Fig. 3.—*A,* Schematic model of single-rooted tooth to demonstrate axis of rotation, *a,* to horizontal thrust, *b*. *B,* Model of multi-rooted tooth demonstrating axis of rotation in bone septum between roots. *C,* Individual post in Korogel turns on a hinge axis of rotation-like single-rooted tooth. Center of rotation at *a*. *D,* Abutments of "bridge" turn on an axis of rotation in Korogel between the "roots" like a lower molar.

axis of rotation to the root end only in reverse order. However, since the axis of rotation is in the apical third of the root of the tooth, the periodontal membrane is under disadvantage to offer much resistance to horizontal force in this region.

The multi-rooted teeth are better prepared by nature to resist horizontal displacement. Fig. 3, *B* illustrates how a lower molar is displaced by distal (or mesial) thrust. On distal thrust, *b,* of Fig. 3, *B,* the mesial root goes up, the distal root moves down and rotation takes place on a center, *a,* lying in the bone septum between the two roots. In other words, a certain amount of translation of the roots occurs and the periodontal fibers of both roots come more completely into play. *The significant difference between the two instances has been unrecognized.* Recognition of the fact provides a means of intelligently utilizing investing tissues at greater capacity.

Movements of teeth occur across a mesiodistal axis of rotation as well as a buccolingual axis, and any number of axes between these extremes. Since human teeth of either jaw exhibit arch form, for each half-jaw the vertical axis of each tooth anterior to a given tooth will be medial (with respect to the median sagittal plane of the body) to the posterior one. For this reason when any two teeth are firmly united together as by splinting inlays or fixed bridgework, the foundational stability of both teeth is greatly enhanced because rotation in response to horizontal thrust must take place on a center *between* the roots of the two teeth. One tooth moves down under the thrust, the other up, depending upon which side of the center it happens to be. In certain of the mandibular movements, the foundational stability of such teeth increases arithmetically; in other movements the mechanical advantage of leverage is gained. When posterior teeth of both sides of either the mandible or the maxilla are firmly united in a fixed prosthesis, the center of rotation is at a considerable distance from the abutments, the translational effect of the roots becomes more pure, and the periodontal membrane of each entire root is called into play. The experimental data substantiate this view.

From a practical standpoint, the significance of this finding is that prostheses which utilize firmly fixed abutments separated by long distances should be very stable to horizontal forces in mastication. A fixed bridge which unites both cuspids and a molar tooth should be very stable to buccolingual as well as anteroposterior forces. Since such constructions are seldom undertaken due to the presence of anterior teeth, precision "attachment-type" bridgework, which approaches closest to the positive coupling of a fixed bridge, is the next best choice. When precision attachments are employed, the torque of a partial denture with cantilever saddle extension over one edentulous posterior region is effectively and safely taken by the cuspid and molar of the opposite side, provided the case is rigid enough across the arch.

I have observed over a long period of time that cantilever bridges (a bridge with a lug at the secondary abutment) exhibit more mobility to horizontal thrust than fixed bridges (fixed at both ends). The stability of the latter is out of proportion to the additional support of the second abutment, and can now be explained by the fact that the second case takes advantage of leverage and thereby gains mechanical advantage. With a hunch that this was the case, I sought a laboratory method to verify my belief—a method to study the rotation of teeth

to horizontal forces and the effects of prosthetic structures on the characteristic movements of the abutment teeth to such forces.

While the investing tissues of the teeth are not "elastic" in the physical sense of the word, which expresses deformation as proportional to the load, they are elastic in the usual application of the term. That is to say, if one pushes laterally against any tooth with reasonable retention in the alveolus, the tooth will be displaced laterally and rebound to a greater or lesser degree when the instrument is removed. This elasticity is, of course, a function of the health of the periodontium. For my laboratory purposes, therefore, I sought an elastic material which would permit fibrous attachment to tooth analogues. Hydrocolloid was the material of immediate suggestion.

Initially pegs were embedded in masses of hydrocolloid. It seemed reasonable to assume that the fibrous nature of the wood would furnish a "periodontal membrane" in conjunction with the hydrocolloid. This laboratory set-up proved impractical, however, as the evaporation of water from the hydrocolloid altered its physical properties, and it was impossible to hold the measured values for the "tooth" rotations. Furthermore, the pegs tended to rise out of their "sockets" and this also seriously affected the observed effects and values.

Subsequent tests were done using Korogel as an investing material and 2½" stove bolts were used as tooth analogues. The head of the bolt was imbedded in the Korogel together with about 1½" of the threads. This depth was maintained constantly to rule out complications due to differences in root lengths. The heads and threads provided "periodontal attachment" and kept the bolt from rising out of the Korogel during the tests. Two nuts at the upper end of the bolt facilitated placing metal ties or "bridge pontics" between selected teeth for the studies of abutment rotations to horizontal forces. In preparing the specimens, the metal ties were prefabricated by cutting strips 12, 24, 36, 60, 84, and 120 mm. from a piece of aluminum stock. The bolts were attached to the ties and the assembly submerged to the desired depth in melted Korogel. The Korogel was then permitted to cool and congeal and the ties were removed preparatory to the tests.

Horizontal forces were applied through a pulley and a ball chain in order to minimize frictional losses. The chain was attached to the individual tooth-post or bridge with sticky wax; the other end supported a weight platform. The dependent portion of the chain and platform weighed 25 Gm. To this initial weight, 50, 100, and 150 Gm. were successively applied. For all computations the upper level of weight applied was constant at 175 Gm. The tests were all done well within the range of elastic limit of the Korogel and no rising or separation took place between the tooth-posts and the investing material.

A metric ruler was fastened to a support in such a position that a long radius could be used in measuring the rotation of each test post or each combination of test posts. No attempt was made to measure the rotation in degrees. For some of the tests a rifle sight was employed to obviate parallax in reading the rotations; later a fine wire pointer was used. The radius of the pointer used in denoting rotation was maintained at constant length for all data reported.

A point to stress at this time is that the rotations of teeth in their sockets are qualities which are not peculiar to teeth. Exactly the same conditions were duplicated in our laboratory model both when the posts were rotated individually, (Fig. 3, *C*) and as multiples, (Fig. 3, *D*). In fact whenever a linear solid is rotated through a semi-solid medium, the characteristic rotations exhibited above take place. If one studies the hole left by rocking a post, imbedded in soil, back and forth before its removal, one will verify the rotation. And, if two corks are attached to opposite ends of a needle and the assembly floated in a glass of

TABLE I

POST NUMBER	ROTATION OF POINTER (mm.)
1	15.0
2	12.5
3	11.8
4	12.0
5	14.0
6	13.0
7	11.5
7	89.8
	12.8 mm. average rotation

TABLE II

POST NUMBER	MM. BETWEEN CENTERS	ROTATION OF POINTER (mm.)
4 & 5	12	8.0
3 & 4	24	6.0
2 & 3	36	5.5
1 & 2	60	6.0
1 & 6	84	6.0
1 & 7	120	6.0

water, to eccentric vertical loading or (if the corks are restrained from pure translation) to horizontal force, one cork will submerge while the other one rises. The center of this rotation will lie between the corks.

RESULTS[8]

The rotation of each test post to 175 Gm. of loading is shown in Table I. The variance in rotation is due to two factors: first, proximity of the post to the side of the pot; secondly, shrinkage of the Korogel which left some posts a little less supported than others. The order of values is, however, quite satisfactory, with an average of 12.8 mm. rotation.

When the posts were united by bridges, a load of 175 Gm. applied at right angles or 90 degrees to the bridge span produced readings as shown in Table II.

With minor variation the rotation of the double posts is shown half that of the individual posts, and this value is constant regardless of whether the abutments are close together or far apart.

When the load is applied in line with the abutments, that is, at 0 degrees, the distance between centers of the abutments is an important factor. At 12 mm. centers, the abutments rotated through a pointer displacement of 10 mm.; at 120 mm. centers, the displacement was 7/8 mm. Obviously the increased spacing of the abutments makes for stability. Table III gives intermediate values. Since rotation occurs upon a center between the posts, the stability of the foundation or its resistance to rotation varies directly as the radius.

TABLE III

	UNITS					
	1	2	3	5	7	10
mm. between post centers	12	24	36	60	84	120
mm. rotation of pointer at 175 Gm. load	10	5 3/4	3 3/4	2 4/5	1 1/2	7/8
Calculated rotation	10	5	3 1/3	2	1 3/7	1

TABLE IV

ANGLE OF APPLICATION OF HORIZONTAL FORCE	MM. ROTATION OF 36 MM. BRIDGE
90°	5.5
60°	4.6
45°	4.1
30°	3.9
0°	3.7

TABLE V

ANGLE OF APPLICATION OF HORIZONTAL FORCE	MM. ROTATION OF 120 MM. BRIDGE
90°	6.0
60°	4.0
45°	2.4
30°	1.3
0°	0.9

The angle of application of the horizontal force also is important to setting up foundational stability. When the horizontal load is applied at 60 degrees, 45 degrees, and 30 degrees successively to the span of the 36 mm. bridge, the readings of the pointer to 175 Gm. of load become progressively reduced and,

therefore, the foundation becomes more stable (Table IV). The two extremes have already been considered.

When the test is repeated, using abutments at 120 mm. centers, stability of the foundation increases as the angle of application of force is reduced (Table V). It should be noted also that since the abutments are separated by a long distance, the radius of rotation is great, and the stability values rise rapidly as the angle of application of force is reduced.

COMMENTS

By clinical observation of the masticatory cycle, one would conclude that when the lower teeth move from "working bite" to centric, the mandible moves bodily sideways. That this is not the case can be ascertained by taking a "Gothic arch" tracing. The lines drawn on the photograph (Fig. 4, *A*) indicate the reason for the geometry of the Gothic Arch. It must be obvious, too, that for right-sided chewers the tangent B_2 to arc B_1 is the direction of the horizontal force playing against the teeth or any prosthetic device of the upper teeth in working bite.

If friction were the only factor to consider, the movement of the mandible from working bite to centric would thrust the upper posterior teeth lingually. But since the action of the mandible is exerted through points on the lower teeth in contact with cuspal inclines on uppers, the upper teeth are thrust bucally. This is particularly true because the contact of the teeth takes place on surfaces lubricated by saliva. The horizontal force component of the vertical bite will vary depending upon the pitch of the occlusal cusps being greater for steeply inclined cusps than flat cusps, and because of the magnitude of the vertical forces the horizontal components may be very significant. In the act of mastication, however, this situation does not exist. When heavy chewing forces occur, food is compressed between the teeth before the cusps puncture through to make contact with the opposing cuspal planes. If the food is tough, the horizontal force produced by the movement of the mandible when moving from working bite to centric must be very significant also. Since the horizontal force component of the vertical bite is in opposite phase with the horizontal movement of the mandible, the two forces tend to cancel each other, and the significant force is axial or vertical.

Because the upper teeth are stationary, the horizontal force of mandibular movement which acts upon the lower teeth is in opposite phase to the upper. It is interesting but not comforting to note that the foundational capacity of the investing tissues in the bicuspid-first molar region is least during the working-bite stroke of the masticatory cycle because the horizontal force is applied at almost 90 degrees, as can be determined by tangent B_2 (Fig. 4, *A*). The cancellation of the horizontal forces just mentioned, however, mitigates the severity of the situation.

It is interesting to note also that nature employs leverage to cope with her mechanical problems. If right lateral position is considered, the contact of the buccal cusps of the lower teeth with the cuspal inclines of the uppers tends to push the uppers out laterally, as just mentioned, while the lowers are being thrust

lingually. The lower teeth, however, can resist this thrust better than the upper teeth can take their thrust because the lowers comprise an inner half-circle of contact. The medial thrust on the lowers merely squeezes them into tighter contact, and all the teeth resist this force by interproximal contact. The upper teeth, however, are an outside half-circle and on being thrust laterally separate one from the other. Interproximal contact does not help the upper teeth. Nature might have solved this problem by making the periodontal mem-

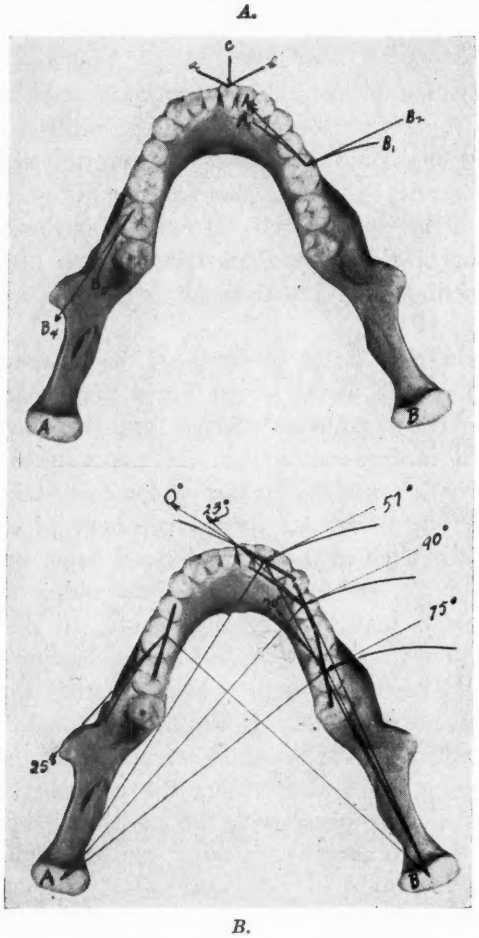


Fig. 4.—*A*, 1. When condyle *A* moves from left protrusive to centric, rotation of the mandible occurs on *B* as center and arc *b* of the Gothic arch is scribed. 2. When condyle *B* moves from right protrusive to centric, *A* is center of mandibular rotation and arc *a* of Gothic arch is scribed. 3. When both condyles move into protrusive, protrusive recording *c* is scribed. (Note: These markings are just reversed for the conventional Gothic arch tracing because the scriber is usually attached to the upper jaw.) 4. In "working bite" when *A* moves from its protrusive position to centric, mandibular rotation occurs on *B* as a center, arc B_1 is scribed which has for its tangent B_2. 5. If the mandible moves past centric, *B* moves into protrusive, *A* becomes the center of mandibular rotation, and arc A_1 is scribed which has for its tangent A_2. 6. In "balancing bite" (right side chewers) *B* is the center of mandibular rotation when *A* moves from protrusive to centric and arc B_3, which has for its tangent B_4 is scribed by this movement. *B*, Angles of application of horizontal forces when the mandible moves from working bite to centric.

brane and bone about these teeth denser than the lowers. But she did not do this; instead she chose to use leverage to resist the horizontal thrust by putting palatal roots on upper molars and sometimes even the first bicuspid.

If the chewing stroke does not stop exactly at centric but the mandible continues on past this position a short distance, the head of the condyle *B* leaves the glenoid fossa to come forward, and rotation begins on *A* as center. The tangent A_2 to arc A_1 indicates that horizontal force is applied in a direction approaching the anteroposterior. The teeth collectively resist this force through interproximal contact. It should be observed that horizontal force in this direction is well resisted by fixed bridgework because the angle of application now approaches 0 degrees. Since the movement of the lower teeth at this time is in an anterior direction, friction will tend to seat upper cantilever bridges supported by a lug at the anterior abutment. By the same token, since the horizontal force on the lower teeth will be equal but opposite in phase, lower cantilever bridges supported as above may be pulled out of lug contact with the secondary when tough or fibrous food exists between the teeth, and the primary abutment will take all the horizontal thrust.

For right-sided chewers the horizontal force on the "balancing side" is directed not buccolingually but anteroposteriorly. In this instance the mandible is turning on a center at *B*. The tangent B_1 to arc B_2 indicates that, if abutments are united in a fixed bridge on this side, foundational capacity of the abutment teeth will be exploited to the fullest because the horizontal force is applied through an angle now again approaching the 0 degree limit. Since the lower teeth are moving posteriorly during this masticatory stroke, long cantilever construction in upper bridges is inadvisable because, unless perfect intercuspation exists, transitional contact of cusps may cause the cantilever to rise out of its seat in the secondary abutment during the milling action, and the primary abutment will take all the powerful horizontal masticatory force directed distally.

Similar mandibular and foundational relations can be obtained for left-sided chewers except that the directions of forces concerned will be reversed.

There is improvement in the capacity of investing tissues to tolerate the horizontal load when abutments anterior or posterior to the premolar-first molar region are firmly united in bridgework. This is illustrated in Fig. 4, *B*. The heavy lines across the centers of the teeth denote fixed bridgework with an abutment at the terminus of each line. The figures denote the angles of application of force at the center of each bridge span as the mandible moves from a lateral working-bite to centric and somewhat past centric occlusion.

The geometry of the masticatory cycle is controversial. Jankelson, Boswell, Kurth and others argue that the masticatory effort is confined largely to the vertical dimension with the teeth well out of contact by the bolus of food and with rather limited lateral deviation of the mandible from centric closure.

According to this school of investigators, translatory movements of both condyles occur during mastication with superimposed rotation of the mandible about the one or the other condyle, depending upon whether chewing is done on the right or left side. In data gathered by this group, it should be emphasized,

lateral movement of the mandible takes place in addition to the large vertical excursion but the mandible returns almost to centric position before the teeth approximate each other. They argue that mastication takes place essentially in the vertical effort and that condylar function is purely adaptive to this movement.

Analysis of Boswell's tracings (Fig. 5), may reveal the following: if a single cycle of Boswell's charts is studied, and if right and left tracings are checked

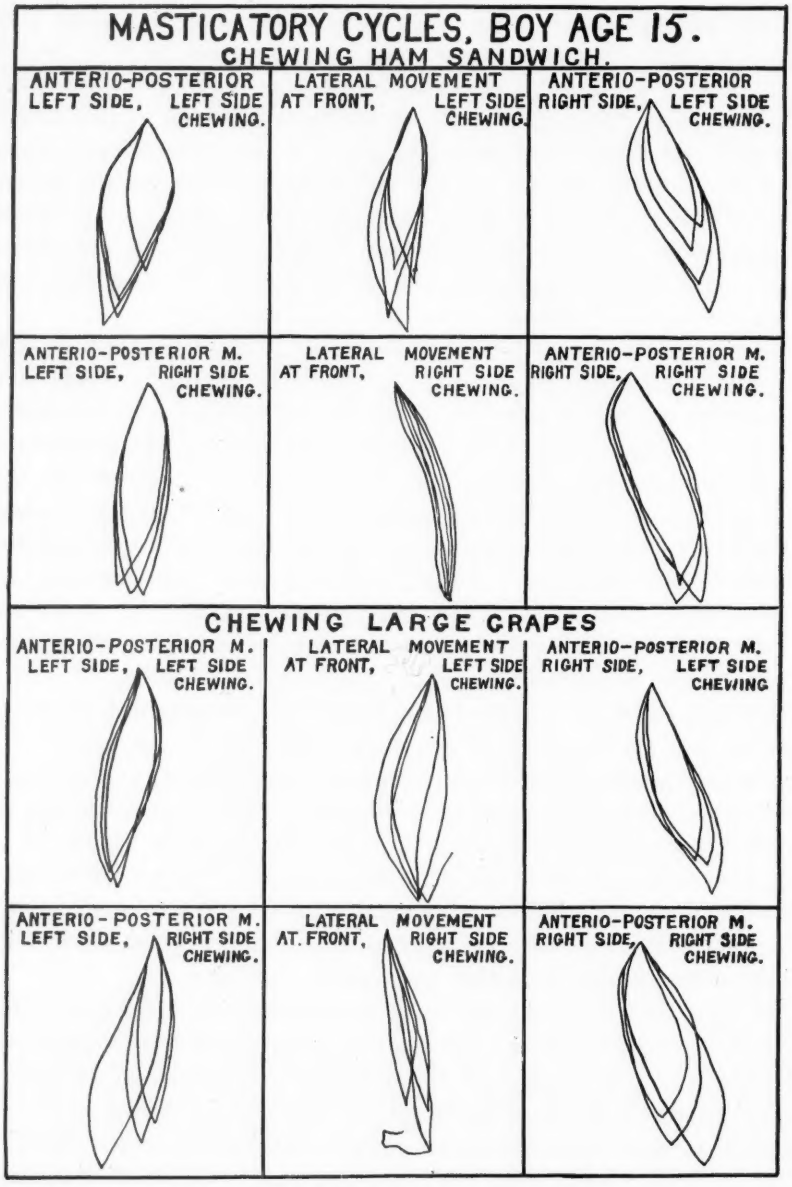

MASTICATORY CYCLES, BOY AGE 15.
CHEWING HAM SANDWICH.
ANTERIO-POSTERIOR LEFT SIDE, LEFT SIDE CHEWING.
LATERAL MOVEMENT AT FRONT, LEFT SIDE CHEWING.
ANTERIO-POSTERIOR RIGHT SIDE, LEFT SIDE CHEWING.
ANTERIO-POSTERIOR M. LEFT SIDE, RIGHT SIDE CHEWING.
LATERAL MOVEMENT AT FRONT, RIGHT SIDE CHEWING.
ANTERIO-POSTERIOR M. RIGHT SIDE, RIGHT SIDE CHEWING.
CHEWING LARGE GRAPES
ANTERIO-POSTERIOR M. LEFT SIDE, LEFT SIDE CHEWING.
LATERAL MOVEMENT AT FRONT, LEFT SIDE CHEWING.
ANTERIO-POSTERIOR M. RIGHT SIDE, LEFT SIDE CHEWING
ANTERIO-POSTERIOR M. LEFT SIDE, RIGHT SIDE CHEWING.
LATERAL MOVEMENT AT. FRONT, RIGHT SIDE CHEWING.
ANTERIO-POSTERIOR M. RIGHT SIDE, RIGHT SIDE CHEWING.

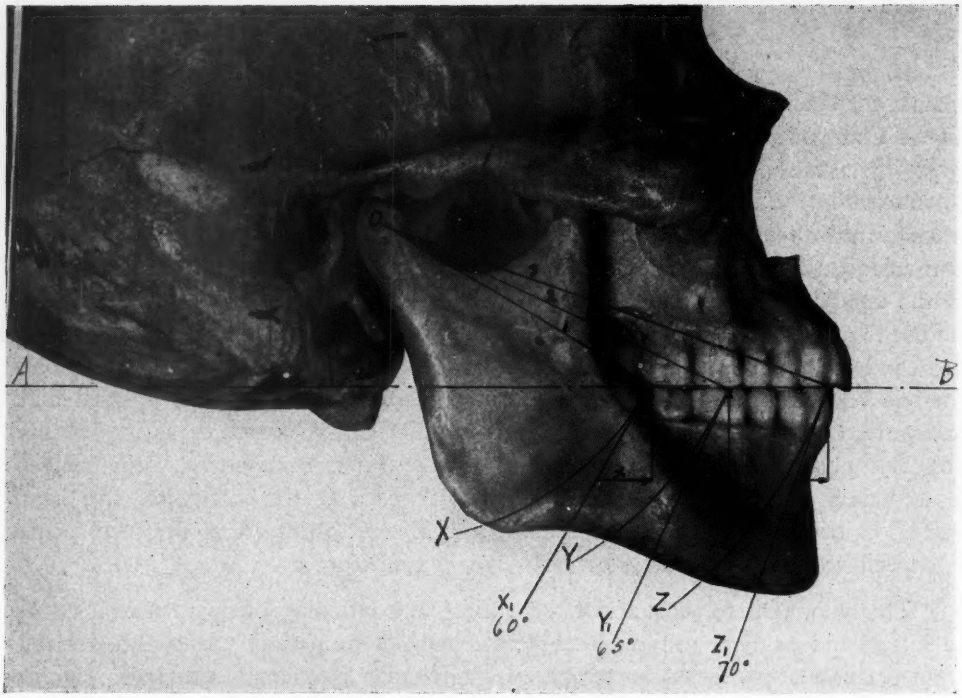
Fig. 5.—Example of some functional mandibular tracings of jaw movements. Note there was no stroke in occlusion, the cycles having their termini at centric occlusion. (Reprinted by permission of Dr. Jesse V. Boswell, JOURNAL OF PROSTHETIC DENTISTRY, May, 1951.)

against the tracing of lateral movement of the jaw, one may see that the mandible moves uniformly backward with opening until translation of both condyles begins. Translation of the condyles occurs where right and left tracings take a downward but anterior turn. The bolus of food is present between the teeth when a rather uniform anterior and upward movement takes place (mandible is turning on its hinge axis, food is serving as a reactance to the closure, heads of the condyles are in their advanced positions). As the food is crushed and softened by the incorporation of saliva, the reactance of the food diminishes and the condylar paths become the reactances of significance to muscle pull. The condyles slip back into their glenoid fossae as can be seen by the upward and backward curve to the right and left tracings. Cuspal contacts assist in this posterior positioning of the mandible as it approaches centric, but cusp contact is secondary to the inclination of the condylar path as the discussion will bear out. The tracings and Jankelson's findings lead one to think that the teeth come into occlusion only in centric or near-centric occlusion.

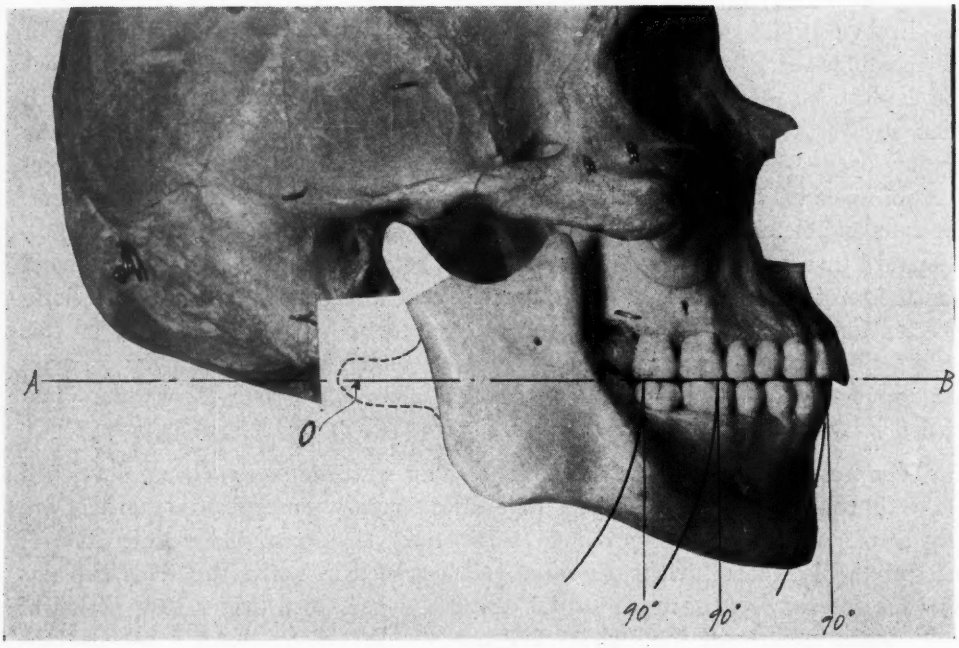
This view fails to account for the pitting and flattening of upper buccal cusps of inlays and bridges and the therapeutic benefits to periodontal health derived from occlusal adjustments in eccentric mandibular relations. Whatever significance the above findings hold as opposed to the conventional views of the masticatory cycle, one fact remains certain—that centric occlusion is the terminus of the masticatory cycle.

From Fig. 6, *A* we can see that—disregarding for the moment translation of the mandible—since the sagittal axis of mandibular rotation is not on the occlusal plane but considerably above it, (*O*, Fig. 6, *A*), centric contact of teeth must always produce an anterior thrust upon all the teeth of both arches. As the jaw opens, the teeth separate at varying velocities and describe varying directions of opening, since the arc of opening and closing for each tooth is different. As the mandible closes, all the teeth have in common, although in varying degrees, a forward thrust as can be seen from the force components x, y, and z. Although translation of the mandible as it approaches centric occlusion sets up posteriorly directed forces on the upper teeth, the reactive forces on the lower teeth by this act are anterior; the powerful force of complete centric closure, when the condyles are completely retruded, is anterior on the upper teeth as well. as the illustration shows.

The forward thrust of the mandible together with the mesial thrust developed by teeth rotations in their sockets to centric loading, as explained earlier, are largely responsible for interproximal abrasion of teeth and the maintenance of interproximal contact; that is, the so-called "mesial drift" of teeth. This explains why the anterior bars of upper partial dentures, when worn over a long period of time, settle into the tissues while the posterior bars drop down. Because the lower teeth interdigitate with the uppers, they follow the mesial migration of upper teeth; the anterior force components of centric occlusion together with teeth rotations are also, therefore, responsible for the imbedding of lower lingual bars into the lingual tissues of the mandible.



A.



B.

Fig. 6.—*A*, When the sagittal axis of mandibular rotation occurs at *O*, the lower second molar, first molar, and lower incisors describe the respective arcs *X*, *Y*, and *Z* whose tangents are X_1, Y_1, and Z_1. It can be seen that each successive tangent has a smaller component of anterior thrust as designated by *x*, *y*, and *z*. This is true because radius *1* approaches the vertical more closely than radius *2* or *3*. *B*, Illustration to show absence of horizontal anterior thrust if the sagittal axis of mandibular rotation, *O*, were to fall on the occlusal plane, *AB*. All the tangents would be perpendicular to the occlusal plane.

Since the tangents of vertical contact of any two teeth in a given half-jaw differ, occlusal abrasion of each of the two teeth supporting a loose-joint cantilever bridge will differ. This may result in a loss of support to the lug with imposition of heavier load on the primary abutment and greater pumping action of the bridge when in use. Variance in the consistency of the bolus may also thrust the two abutments apart with excessive loading of the primary abutment. Fully fixed bridgework prevents independent migration of teeth and preserves desirable relationships. Furthermore, fixed bridgework makes maximum use of the foundational capacity of the investing tissues because the horizontal thrust of centric occlusion is directed anteroposteriorly, that is, at 0 degrees with respect to posterior abutments.

The anterior thrust of centric occlusion must always occur in human dentition because of the anatomy of the mandible. Pure vertical closure without anteriorly directed horizontal force components could only occur if the sagittal axis of mandibular rotation, *O*, of Fig. 6, *B*, were in line with the occlusal table of the teeth. Under these circumstances, in centric occlusion the tangents to the arcs of closure of all the teeth would be perpendicular to the occlusal table of the teeth.

CONCLUSION

Dentists should take advantage of the leverages which nature affords to counteract the leverages which man must impose through dental prostheses. Fixation of abutments should be employed to take maximum advantage of the foundational capacity of weakened investing tissues. Fixation provides the mechanical advantage of leverage and simultaneously restricts the excessive tooth movements which exacerbate local infectious processes. The reason smaller abutments may be used with split joint cantilever bridgework is that the foundational structures give. When the foundational structures pick up rigidity or stiffness, the abutments are wracked more, and the cement gives way because it is the weakest link in the system. But, this proves the premise. To offset the problem of structural failure, cut substantial abutments.[4]

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WARPAGE PRODUCED BY SOLDERING WITH DENTAL SOLDERS AND GOLD ALLOYS

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DENTAL RESTORATIONS have two chief purposes: One is to restore lost function, and the other is to prevent further loss of function. In order to attain these objectives dental restorative procedures must be exact. The highest degree of accuracy is demanded in the field of fixed bridge restorations. The bridge must resist the forces of displacement to a much greater degree than the single restoration. Casting techniques have been developed which can give very accurate results. Even so, the abutments can fit exactly, and the bridge fail to go into place properly because of warpage during the soldering procedure.

There are many suggestions which have been offered for the soldering operation and for the treatment of the restoration after it is soldered. One investigator says the restoration should be plunged while still hot after the solder has flowed.[1] Another one says that the restoration should be cooled slowly, but after it is removed from the investment it should be heated to a cherry red color and plunged.[2] Some say the pieces to be joined should be in contact when soldered,[1,3] while others suggest that the parts be separated.[2,3] The use of an investment that expands has been suggested.[1,3,5] Vopata[5] suggests the use of the electrowelding technique. In the literature reviewed, only one precision method of soldering is discussed.[6] There seems to be little scientific evidence offered in support of any of these statements. With so many different ideas offered the field of soldering is confused, to say the least.

At the present time, there is only limited agreement on soldering technique and after treatment. It is usually suggested that the operation should be completed as rapidly as possible after the solder begins to flow. Another point of agreement is that a minimum of solder should be used. Of course, a reducing flame should be used in the operation.

The purpose of this study was to observe the effect of the soldering operation on differently shaped joints, and under different conditions, and to observe the effect of various treatments following the soldering operation. An attempt is made to point out some of the variables of the soldering operation and ways to control, to some extent, these variables.

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Of importance to this discussion is the fact that solders contract upon solidification. This contraction is accepted as being 1.25 per cent, essentially the same as the other gold alloys.

EQUIPMENT AND PROCEDURE

The measurement of any change produced in a bridge during the soldering operation is a difficult procedure. The bulk of the solder on the usual bridge is in the form of a wedge with the edge of the wedge at the contact point, and the base of the wedge toward the cervical margin. Since most of the solder would be in this area, the distortion should occur here. The distortion would be in more than one plane because there would also be the possibility of a rotational distortion. The wedge area is, then, the critical area of distortion.

In order to determine the extent of warpage in this area, a device was prepared to measure accurately any change during the soldering operation. Two pieces of Ney's Platinum Gold Paladium 18 gauge wire were arranged in the form of a V. The solder was flowed at the base of the V. In order to keep the wires in the exact position desired, they were fastened to flat aluminum block as shown in Fig. 1.

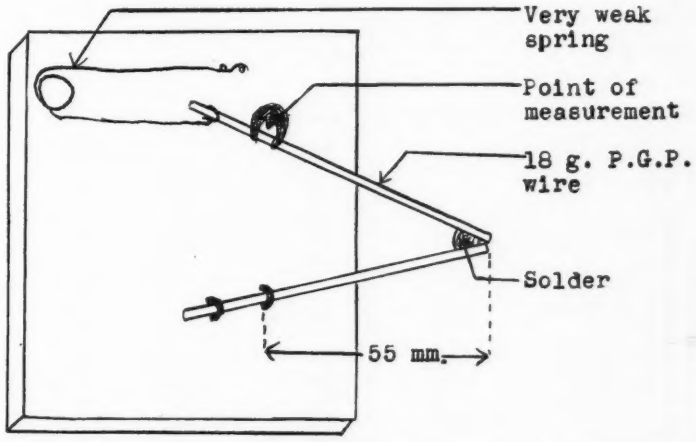

Fig. 1.—Sketch of the aluminum block with the wires in place for soldering. Insert shows the point at which measurements were made.

The one wire was attached rigidly to the base. The second wire was given freedom to move while held in position by a very weak spring that supported this wire against a reference point and against the other wire. This spring was strong enough to hold the wire in place but not strong enough to materially affect any force exerted by the cooling solder. A guide permitted the second wire to move in one plane only. All measurements were taken from a fixed reference point with a comparascope.

The tips of the wires were bent to simulate various shapes to be soldered when in contact. These shapes are shown in Table I. Bars of cast gold, 5 mm. wide, 2 mm. thick, and 15 mm. long, were substituted for simple wires in some of the

TABLE I

SHAPE OF JOINT*	TRIALS	SOLDERING CONDITIONS AND AFTER TREATMENT	AVERAGE SHIFT IN MM.	NUMBER OF TRIALS	S^2 VARIANCE	S STANDARD DEVIATION
joint 2¼ mm. joint 1¼ mm. Wire	A	No investment—bench cool	0.8728	10	.1073996	.1034
	A_1	No investment—bench cool	0.6670	2	.000162	.0127
	A_2	No investment—bench cool	0.5480	2	.00800	.042
	B	No investment—spray cool	0.9512	4	.151641	.1228
	C	Invested—bench cool	0.5081	6	.017517	.13228
	D	Invested—plunge	0.7555	4	.013459	.1157
	D_1	Reheat no investment—plunge. Refer to Table III				
 Wire	E	No investment—Bench cool	0.2450	4	.006338	.07956
	F	No investment—plunge	0.2773	3	.000045	.0067
	G	Invested—bench cool	0.1250	2	.000868	0.029
	G_1	Reheat no investment—bench cool. Refer to Table III				
	H	Invested—plunge	0.1137	3	.003845	0.06196
 Wire and Inlay	I	Invested—bench cool	0.2128	5	.016546	.12845
	I_1	Invested reheat—bench cool. Refer to Table III				
	J	Invested—plunge	0.2551	5	.081988	.2861

Wire	K	No investment—bench cool	0.4650	3	.002454	.0495
Bar	L	No investment—bench cool	0.7810	4	.029773	.17233
	M	Invested—bench cool	0.2348	4	.16933	.1300
	N	Invested—plunge	0.5082	4	.036470	.1910
Bar	O	Invested—bench cool	0.2545	4	.007245	.08508
	P	Invested—plunge	0.4287	4	.003165	.0562
Bar	Q	Invested—bench cool	0.1017	3	.015717	.1250
	R	Invested—plunge	0.2722	3	.003579	.0597

*All soldered joints approximately 4 mm. in length unless otherwise stated.

tests (Table I, L to R). All measurements for the bars were made in the same manner as the wires, using the same reference point and the same equipment.

The investment* used has a setting expansion of 0.25 per cent and a thermal expansion of 0.45 per cent; these give a total expansion of 0.70 per cent. The parts were invested heavily to prevent distortion during soldering.

Ney's 650 fine rod type solder was used for all tests. The flux used was Ney's paste soldering flux. The solder was melted with a conventional air and gas hand torch. All invested joints were heated rapidly after the investment was dried. The soldering operation was completed as quickly as possible.

In soldering without investment, the wires were heated to red heat. The solder was touched to the tip of the rigid wire at the V point. As the solder melted it filled the joint by capillary action. Then the unit was gently removed from the flame. Depending upon the test, the joint was either bench-cooled or quenched in water while still red hot.

To further observe this effect of distortion from shrinkage of solder, some tests were conducted with an inlay insert which was cast to fit the V accurately. This inlay was securely held in position with investment.

It is a common practice to heat and plunge a restoration in acid. In order to determine the effect of reheating after soldering, several series of reheats were tried. The joint to be tested, in some trials, was placed in the flame and heated to redness, then plunged immediately. In other instances the joint was first invested, then heated, investment and all, to red heat and either allowed to bench cool or was plunged. After each of these treatments the distortion was measured.

All displacements due to the soldering, reheating, and cooling were measured with a microscope equipped with a filar eyepiece. The displacement was measured between the wire and the point of reference against which it rested when soldered. The aluminum block and the joint were cooled to room temperature before any measurements were taken.

ANALYSIS OF DATA

All investigations are subject to bias. Probably this cannot be entirely eliminated because of prejudices, but this bias can be reduced to a minimum in the interpretation of the results by means of statistical tests. Significance tests based on the differences between the means existing between two different conditions, and the standard deviations of the samples in the mean were used. This F-test was based on a Null hypothesis that the samples were from the same statistical universe. If beyond the normal limits, then the samples were from different universes and a real difference existed between the two sets. Usually those values which fall between 10 per cent and 5 per cent are considered slightly significant. To further reduce the bias factor all conclusions were based on the following criteria. Those values falling in the 5 per cent to 1 per cent range were judged to be slightly significant, while those which were below 1 per cent were judged to be significant or very significant.

*Ransom and Randolph soldering investment.

The significant difference between any two tests was determined in the following manner. A Null hypothesis was established to judge significance of samples. As a hypothesis to be tested it is first assumed that the samples in question do not exhibit any real difference, that is, that they are random samples drawn from the same universe. The method of Daves[7] was followed for determining the statistical significance of these tests.

DISCUSSION OF RESULTS

In Table I are shown the shapes of the various joints studied along with the various soldering conditions after treatment and average displacement. The number of trials, the variance, and the standard deviations are also shown in Table I.

Group 1 in Table II shows the effect of the length of the joint on the distortion produced. In general a shorter joint will have less distortion than a longer joint.

The shape of the joint affects the distortion as is shown in Group 2 on this table. As typical of this group, trial A and E are noticed. A, which is a typical V shaped joint, as compared with E, which is a precision fit of the wire joint, shows that the more exact the fit the less distortion produced in the soldering operation.

Group 3 of Table II demonstrated the value of investment in reducing the distortion produced during the soldering operation. For example, by comparing trials L and M investment is shown to be very significant in reducing distortion, but only if the investment is allowed to bench cool after the soldering operation is completed.

Group 4 shows the effect of plunging the restoration after the soldering operation is completed. This series of tests shows that the plunging of an invested restoration will cause greater distortion than if it is allowed to bench cool.

Plunging an invested restoration after soldering tends to produce almost as much change as would occur if no investment were used. This is shown in Group 5. If then the value of the investment to hold the pieces in place is utilized, it must be allowed to bench cool after the soldering operation is completed.

Table III shows the disproportion produced by the reheat treatments. These are changes produced in the joint by repeated heatings. In D_1 the joint was in the shape of a V. The joint was about 4 mm. in length. The soldered joint was heated to a cherry red and plunged in water to cool. An examination of Table III shows that the changes produced by reheating are not constant. These changes occurred regardless of whether the sample was invested, bench cooled, or plunged. The greatest changes were produced in the sample which was not invested and plunged. The only way to control these changes is to reduce the number of heatings of a joint to a minimum.

There seems to be a relationship between the original difference and the difference produced by reheating. Those joints which had a large displacement had increased changes induced. The important thing to remember from Table III is

TABLE II. STATISTICAL COMPARISONS OF CONDITIONS INVESTIGATED AND ANALYSIS OF VARIANCE

GROUP	TRIAL	DEGREE FREEDOM		SUM OF SQUARE	VARIANCE	V_1/V_2	5%	1%	COMMENT
1 Effect of length of joint	A A_1	1 10	Between samples Within samples	0.0600 0.1115	0.600 0.0112	5.35	4.96	10	Slightly significant
	A A_2	1 10	Between samples Within samples	0.1324 0.1056	0.1324 0.0105	12.54	4.96	10	Significant
2 Effect of shape of joint	A E	1 12	Between samples Within samples	0.9639 0.1337	0.9639 0.0089	86.83	4.75	9.33	Very significant
	A K	1 11	Between samples Within samples	1.7699 0.1098	1.7699 0.099	17.8	4.84	9.65	Significant
	M O	1 6	Between samples Within samples	0.0292 0.0242	0.0292 0.0040	7.3	5.99	13.7	Slightly significant
	M Q	1 6	Between samples Within samples	0.0340 0.0328	0.340 0.0054	6.1	5.99	13.7	Slightly significant
	C G	1 8	Between samples Within samples	0.1663 0.0238	0.1663 0.0029	57.4	5.32	11.3	Very significant
	C I	1 6	Between samples Within samples	0.2214 0.0185	0.2214 0.0031	71.4	5.99	13.7	Very significant
3 Invested, soldered, and bench cooled compared with no investment, soldered, and bench cooled	A C	1 14	Between samples Within samples	0.4986 0.1249	0.4986 0.0089	55.89	4.60	8.86	Very significant
	E G	1 4	Between samples Within samples	0.0191 0.0073	0.0191 0.0016	10.55	7.71	21.2	Slightly significant
	L M	1 6	Between samples Within samples	0.6088 0.0468	0.6088 0.0078	80.6	5.99	13.7	Very significant

4 Invest, solder, and bench cool compared with invest, solder and plunge	C D	1 8	Between samples Within samples	0.3976 0.1186	0.3976 0.0148	22.4	5.32	11.3	Very significant
	G H	1 3	Between samples Within samples	0.0001 0.0049	0.0001 0.0016	0.063	10.1	34.1	Not significant
	I J	1 8	Between samples Within samples	0.0123 0.0352	0.0123 0.0044	2.29	5.32	11.3	Not significant
	M N	1 7	Between samples Within samples	0.1619 0.0636	0.1619 0.0075	21.6	5.59	12.2	Very significant
	O P	1 6	Between samples Within samples	0.0877 0.0145	0.0877 0.0024	36.5	5.99	13.7	Very significant
	Q R	1 6	Between samples Within samples	0.0550 0.0193	0.0550 0.0032	17.2	5.99	13.7	Significant
5 Invest, solder, and plunge compared with no investment, solder, and bench cool	A D	1 12	Between samples Within samples	0.0393 0.1209	0.0393 0.0100	3.93	4.75	9.33	Not significant
	E H	1 5	Between samples Within samples	0.0295 0.0102	0.0295 0.0020	14.7	6.61	16.3	Slightly significant
	L N	1 7	Between samples Within samples	0.17684 0.0664	0.17684 0.0095	18.8	5.59	12.2	Significant

that reheating causes changes whether the joint is invested or not. These changes are not constant, not predictable, and not controllable, and they may be of a large magnitude.

TABLE III. EFFECT OF REHEATING ON DISTORTION OF JOINT

G_1		D_1		I_1	
ORIGINAL MEASUREMENT	INDUCED CHANGE	ORIGINAL MEASUREMENT	INDUCED CHANGE	ORIGINAL MEASUREMENT	INDUCED CHANGE
0.103 mm.		0.475 mm.		0.280 mm.	
0.115 mm.	0.012 mm.	0.425 mm.	0.050 mm.	0.417 mm.	0.137 mm.
0.144 mm.	0.029 mm.	0.522 mm.	0.097 mm.	0.549 mm.	0.132 mm.
$\bar{x} = 0.020$ mm.		1.135 mm.	0.613 mm.	0.573 mm.	0.024 mm.
		0.904 mm.	0.231 mm.	$\bar{x} = 0.097$ mm.	
		1.078 mm.	0.164 mm.		
0.147 mm.		$\bar{x} = 0.231$ mm.		0.120 mm.	
0.279 mm.	0.132 mm.			0.222 mm.	0.102 mm.
0.207 mm.	0.072 mm.			0.285 mm.	0.063 mm.
$\bar{x} = 0.101$ mm.				0.355 mm.	0.070 mm.
				$\bar{x} = 0.078$ mm.	
				0.261 mm.	
				0.479 mm.	0.218 mm.
				0.480 mm.	0.001 mm.
				0.696 mm.	0.216 mm.
				$\bar{x} = 0.145$ mm.	

APPLICATIONS TO DENTISTRY

In the construction of a bridge or other precision appliance, any factor which will cause distortion should be eliminated. This is of importance if the tissues are to remain healthy. Any suggestion for improving the quality of the restorations should not entail added steps. The suggestions must be simple, and, if possible, save construction time. As shown from this study, several factors materially affect the distortion produced during the soldering operation.

The dimensional changes produced in both the wire and the Bar "V" joints show that the distortion in a typical bridge would be similar to that illustrated in Fig. 2.

The wedge-shaped piece of solder will contract and draw the cervical margins together slightly. The center of movement will be the contact point, and the arms of the V will be the cervical margin. The resulting distortion pulls the cervical margins out of alignment.

The wires and the bars had less distortion when the investment was allowed to bench cool after the soldering operation was completed. As applied to dentistry, this indicates that bench cooling should be used in all soldering operations. Restora-

tions should not be quenched to cool since excessive distortion may result. Since all soldering of a precision nature is done with an investment, free hand soldering is not considered in this study.

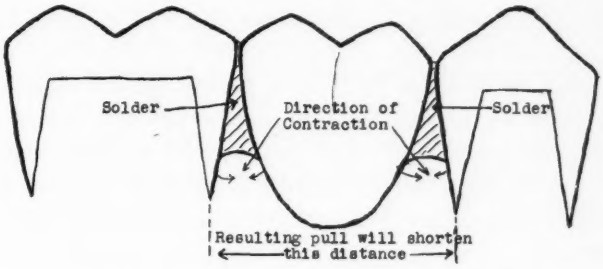

Fig. 2.—Typical bridge showing the effect of the construction of the solder.

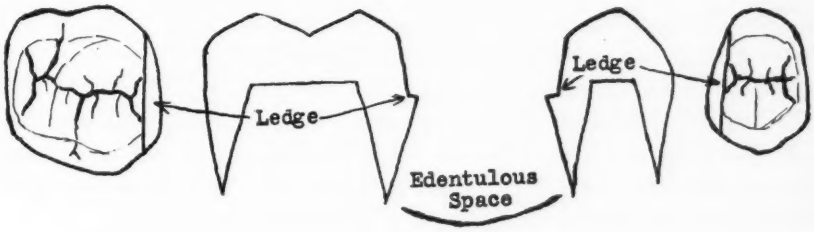

Fig. 3.—Abutments carved with ledges.

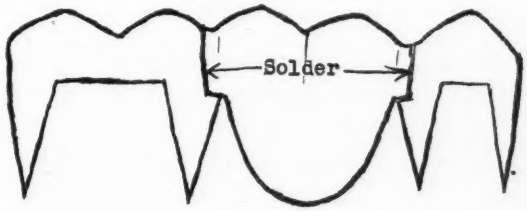

Fig. 4.—The pontic carved to fit the ledges of the abutments.

From the comparisions of Group I, Table II, it is obvious that less distortion is produced with a reduction in the bulk of solder used. This applied to dentistry means that the solder should not be allowed to flow over the restoration beyond the confines of the precision joint. This can be controlled by investing with care and by the use of antiflux.

The distortion produced by reheating, whether the metal is invested or not, is shown in Table III. These results indicate that the practice of heating a restoration to red heat, and plunging it in acid to pickle it, can produce significant changes.

No restoration, whether invested or not, should be plunged in any liquid while hot. Pickling can be done just as well by placing the restoration in acid and heating to the boiling point.

(Considering the root end of an abutment tooth as the end of a lever, and the solder joint as the fulcrum, the distortion observed in these tests may not be too extreme.)

The more exact the fit of the parts to be joined, the less distortion is produced, as is shown in Table II, Group 2. This is true whether the joint was made of wire or of bars, and can be applied to dentistry by at least two methods. The first is by the use of precision inlays fitting furrows between the parts to be joined.[6] The only disadvantage is that it requires the added work of constructing inlays for the joints.

The second way this can be accomplished is by making a joint similar to Q and R (Table I), which produced the least change. The parts must be exact. The pontics, when carved, are made with ledges on the edentulous side as shown in Fig. 3. The abutments are cast as desired. The abutments are placed on the master cast. The pontics are carved to fit onto these ledges as shown in Fig. 4.

After casting the pontics, cleaning, and pickling them by boiling (if the relations are correct), the next step is to flux the parts which will be in contact with the step or the ledge of the abutment and the corresponding parts of the pontics. Then the restoration is invested and soldered. It will take only a film of solder to complete the joint. The solder will flow by capillary action. It is essential to flux the parts before investing the restoration.

The soldered joint is allowed to bench cool after the soldering is completed. This produces a strong joint as free as possible from warpage.

SUMMARY

To summarize the results of all of these trials, it can be said that the more precise the fit of the parts to be soldered, the less they will be distorted. This is true whether the joints considered are of wires or of bars. The amount of solder used to produce the joint is important. The less solder used to produce the union, the less the distortion.

An invested joint will have less distortion than one of a similar shape which is not invested. This is only true when the joint which is invested is allowed to bench cool after the soldering operation is completed. The bench cooled trials showed less distortion than those which were plunged. The best results are obtained with a precision fit of the joint which is invested and allowed to bench cool after the soldering operation is completed. The reheating of a joint is contraindicated because it will produce nonuniform changes.

CONCLUSIONS

1. The less solder used, the less distortion produced.
2. Bench cooling a soldered joint produces less distortion than plunging. Plunging an invested joint produces significant distortion.

3. Reheating and plunging, or reheating and bench cooling can produce significant changes in a restoration.

4. The more exact the fit of the parts to be joined, the less will be the distortion produced.

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MANDIBULAR SUBPERIOSTEAL IMPLANT DENTURE TECHNIQUE

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FULL DENTURE PROSTHESIS by the subperiosteal implant method is a recently developed dental specialty. Perhaps it could be considered a subspecialty of both oral surgery and prosthodontics. In any event, a high degree of cooperation and coordination between the oral surgeon and the prosthodontist, each with a mutual understanding of the responsibilities and problems of the other, is required for success. Furthermore, under the supervision of the prosthodontist, the same degree of cooperation is required with the dental laboratory technician who fabricates the implant with its protruding abutments and the removable superstructure for replacing the teeth.

RESPONSIBILITIES OF THE PROSTHODONTIST

Usually it is the prosthodontist who sees the patient first, as the essential problem is the replacement of natural teeth by means of a suitable dental prosthesis. First, he must be sure that an implant denture is actually indicated. This means that conventional dentures made by competent hands must have been thoroughly tried and proved unsatisfactory. Whether the causes of failure are physiologic or psychologic or both is immaterial. The prosthodontist must be sure that the patient thoroughly understands the principles of the implant denture and the uncertainty surrounding its eventual place in dentistry, and still genuinely wants to have it made.[1] The prosthodontist is, of course, responsible for the construction of the dentures with all the associated problems of esthetics, phonetics, vertical dimension, adjustments, relines, repairs, and reconstructions. If possible, he should establish the surgical jaw relations and make the surgical impression, and naturally he must prepare the necessary surgical trays and occlusion rims. He should consult with the oral surgeon regarding the exposure and access required. Considering carefully any suggestions the oral surgeon may make, he designs the implant and supervises its construction in the dental laboratory. He should be present at the surgical insertion of the implant, observing the fit of the implant against the bone, making any required alterations to the implant framework, and consulting with the oral surgeon regarding any possible modifications to the bone surface which might result in a better fit of the implant against the bone.

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RESPONSIBILITIES OF THE ORAL SURGEON

The oral surgeon is responsible for both surgical operations including the preoperative work-up, postoperative treatments, and follow-up. His is the responsibility for ordering, checking, and evaluating the complete medical examination by a competent physician to ascertain that no contraindications to the surgery or to the implant exist. The surgeon should draw the prosthodontist's attention to any anatomic considerations which might require a modification in the design of the implant, such as the location of unfavorable tissue, the mental foramen, or the mandibular canal. At the first operation for establishing the surgical jaw relations and making the surgical impression, he must make it as easy as possible for the prosthodontist, so he can obtain maximum accuracy with the minimum trauma. If the prosthodontist cannot be present, the surgeon must be ready to perform these functions himself. At the second operation for the insertion of the implant, he must be sure that the casting is finished properly to avoid irritation, and that when it is in place it does not impinge upon soft tissue. During the follow-up period he must constantly be on the alert for early signs of necrosis, especially at the suture line. Furthermore, he is responsible for the patient's local and systemic well-being until complete healing of the tissues is established. He should consult with the prosthodontist regarding the design and construction of the implant, drawing attention to any factors which would facilitate its insertion or increase its tolerance by body tissues.

Because at the present time the primary indication for the implant denture is as a solution for the chronic problem of the unsatisfactory full lower denture, only the mandibular implant will be discussed, although occasional indications will be found for maxillary implants.

PART I. PROSTHODONTICS

Roy L. Bodine, Jr.

The role of the prosthodontist is no less important than that of the oral surgeon who implants the framework with its four protruding abutments under the mucoperiosteum of the mandible. After a number of postoperative treatments the work of the oral surgeon is largely completed. The prosthodontist, however, is the one to whom the patient will look for the comfort, masticatory efficiency, and appearance of his dentures for the rest of his life.

When it is absolutely certain that an implant denture is indicated and desired by the patient (Fig. 1), and the complete medical work-up has been made, evaluated, and found satisfactory by the oral surgeon, the implant denture construction begins. Inasmuch as a mandibular implant denture always deserves a new opposing denture, conventional upper and lower dentures are begun and carried through an acceptable try-in stage. These dentures should be constructed by sound prosthodontic procedures. It is especially important to keep the lower teeth over the crest of the ridge.

When the try-in is mechanically and esthetically satisfactory, the prosthodontic preparation for the direct surgical impression begins. An impression is made in

a high-heat pressure producing modeling compound with the cheeks and lips relaxed. An attempt is made to get the maximum possible buccal and labial overextension. The entire retromolar area, external oblique ridge, and as much as possible of the symphysis should be clearly defined. Lingually, the mylohyoid ridge, mandibular torus, and the superior genial tubercle should show in the impression.

Prior to making the acrylic resin impression tray, the outline is drawn on the resultant overextended cast. This outline should include, one-third of the retromolar pad, one-half of the external oblique ridge, a part of the anterior prominence of the symphysis, and should terminate lingually just short of the mylohyoid ridge, but including a little of the mandibular torus and the superior genial tubercle. The tray should be reinforced with coathanger wire and be thick in its central part, tapering to a thin edge at the borders. Besides a small handle in the anterior region of the tray, a knob in the second bicuspid region of each side to afford a finger grasp for removal is helpful. Two or three identical trays should be made because reliance is never placed upon a single impression.

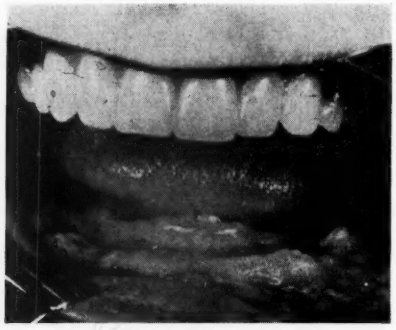

Fig. 1.—Common indication for implant denture. Extreme resorption of alveolar process makes a conventional denture unsatisfactory.

It is extremely important that the four implant abutments be located in their proper mechanical and physiologic relation with both the superstructure teeth and with the mandible. The lower cuspids and first molars are removed from the trial setup. With a lead pencil held vertically, marks are made on the crest of the ridge in the center of the resulting spaces (Fig. 2). An abutment locater is then made of acrylic resin on this conventional cast with four holes which will coincide exactly with the marked centers of the cuspids and first molar teeth (Fig. 3). This simple locater will be used by the oral surgeon at the beginning of the surgical impression for locating the abutment grooves.

In preparation for establishing the surgical jaw relations, which will be done at the same time as the making of the surgical impression, the original occlusion rims are keyed together to maintain the previously established vertical dimension and centric relation. The base of the lower occlusion rim, which should be of acrylic resin, is trimmed until it is smaller than the surgical impression tray and will easily pass a mucoperiosteal elevation which will admit the impression tray. The tissue side of this cut-down baseplate is coated with 2 or 3 mm. of a soft impression wax.

THE SURGICAL IMPRESSION

Although the surgical impression is a surgical operation for which the oral surgeon is responsible, its sole purpose is to enable the prosthodontist to obtain an accurate impression of the mandibular bone. Therefore, anything the oral surgeon can do to make the prosthodontist's work easier or more accurate is clearly indicated.

Fig. 2.

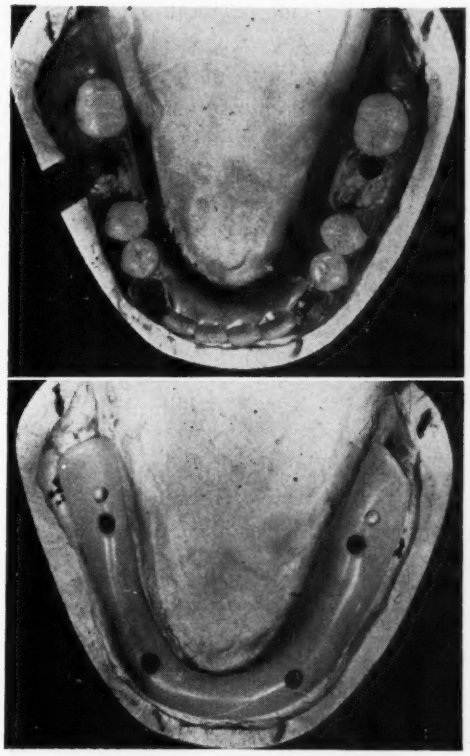

Fig. 3.

Fig. 2.—Locating position of abutments from conventional trial denture by removing cuspids and first molars and marking with pencil on crest of ridge.

Fig. 3.—Abutment locator with holes for transferring location of abutments to mouth so that grooves can be prepared in proper position.

Grooves through the remnants of the alveolar ridge are a desirable procedure, especially for the cuspid abutments, to give a definite location for the abutments and to enable the primary cross struts supporting the abutments to be countersunk flush with the bone surface. Because these grooves must be located at the exact site of the cuspid and first molar teeth, the prosthodontist assists the oral surgeon in the use of the abutment locater.

The surgical jaw relations should be established before the surgical impression is made so there will be no possibility of its being forgotten. When the oral surgeon has elevated and retracted the mucoperiosteum sufficiently to allow easy

insertion of the impression tray, the original upper occlusion rim is inserted, and then the cut-down lower occlusion rim, which has been lined with the soft impression wax, is placed directly on the exposed mandibular bone. As the patient slowly closes into centric relation, the lower occlusion rim is adjusted until it keys with the upper, and enough closing pressure is applied to force the mandibular bone into the soft impression wax. This will produce a reasonably accurate centric relation record, and a vertical dimension which may be reduced about a millimeter, by means of which the surgical cast can be mounted in its correct relation to the conventional upper cast.

In making the surgical impression, low-fusing compound in the amount of from one to two sticks is seared to the inside of the impression tray and thoroughly softened in sterile water at 125° F. The tray is carefully centered and seated slowly but firmly onto the bone surface so that excess compound is forced out on all sides. When seated as far as possible, it is allowed to cool without chilling. The hardening compound is watched closely, and while still slightly flexible, the tray is raised slightly once or twice by means of the posterior knobs and firmly reseated. When completely hard, it is removed and examined to be sure that an accurate bone impression has been obtained (Fig. 4). As bone is incompressible, areas of tray showing through the compound are not objectionable. It is impractical to add compound in any area, and any attempt to do so will result in a distorted impression. An unsatisfactory impression should be remade completely. Regardless of the length of time involved, if in the surgeon's judgment the patient's condition will permit, two usable impressions should be obtained.[2] After closure there is no opportunity for a remake and accidents might render a single impression or cast unusable.

Fig. 4.—Surgical impression made with low-fusing compound in a specially prepared tray.

DESIGNING THE IMPLANT

When the surgical cast has been properly mounted (Fig. 5), the prosthodontist designs the implant taking into consideration any pertinent surgical factors recommended by the oral surgeon (Fig. 6). This cannot be left ethically to the technician no matter how skilled in implant construction he may be. A widespread, open-spaced framework has replaced the fine meshwork used in early implants.[3] Most of the strength and support should come from the buccal periphery of the framework which is placed on the external oblique ridge and adjacent horizontal surfaces. The labial periphery of the framework is placed well anteriorly so it crosses

the superior portion of the symphysis. The lingual periphery is located a millimeter short of the mylohyoid ridge, and is as thin as strength will permit because the lingual mucosa is thin and an excessive subperiosteal bulk of metal may not be tolerated. The lingual periphery distal to the molar abutments should be eliminated if the tissue is unusually thin in that area. The implant must be of rigid construction so masticatory stresses will be transmitted to a wide mandibular area rather than being concentrated under each abutment.

Fig. 5.

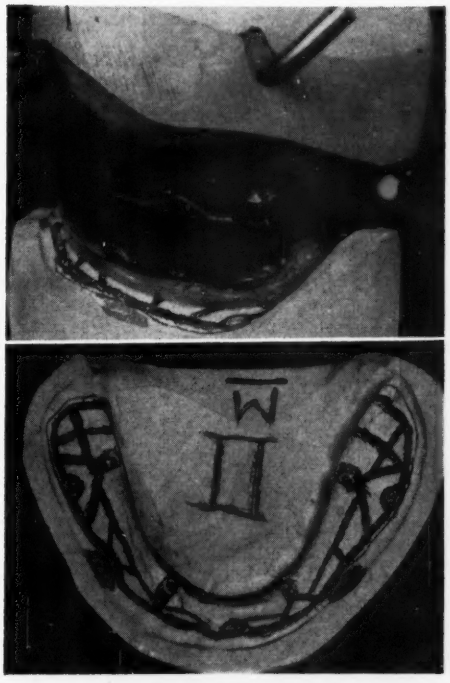

Fig. 6.

Fig. 5.—Surgical vertical and centric jaw relations. Surgical bone-surface cast is mounted in the correct vertical and centric relations with the upper conventional cast.

Fig. 6.—Implant design by the prosthodontist. Abutments, screw holes, peripheral framework, and primary and secondary struts are located.

The ridge area which will be under the incision line at the insertion is left open and not crossed by metal except by the primary struts which support the implant abutments. The anterior abutments are located in the prepared grooves at the previously determined sites of the cuspid teeth. The posterior abutments are located in the first or second molar areas, as space permits, and placed well lingually near the mylohyoid ridge. Because the gingival crevice which forms around an implant abutment is physiologically and histologically similar to the gingival crevice around a natural tooth,[4] the necks of the abutments which will be in contact with the penetration of the mucosa should be constricted only slightly and resemble as closely as possible the gingival contour of natural teeth.

It is common practice to use screws for initial fixation of the implant, although Lew[5] has shown that direct fixation is not necessary when the implant is properly stabilized. If screws are used, the three screw holes which are prepared to match and countersink the heads of the small 5 to 7 mm. long screws, are located one near the midline as far to the anterior as possible in the depression to the right or left of the prominence of the symphysis, and one on each side in the buccal periphery opposite or posterior to the molar abutments at the most convenient place for use of a long screwdriver.

The abutments themselves and the corresponding attachments of the superstructure may be variously prepared for clasps, precision attachments, or a combination of both. The superstructure frame consists of four removable attachments (made to fit the implant abutments) which are united by heavy rigid connectors. The lower teeth will be joined to this framework later with acrylic denture resin to complete the removable superstructure. The superstructure frame must be completed by the laboratory to fit the abutments, and delivered with the implant (Fig. 7). It should have accurate fit, stability, and adequate retention, yet be removed easily. The bar connecting the attachments must be of strong and rigid construction to preclude any possibility of distortion in handling or in processing. Needless to say, both implant and superstructure frame must be made of a proved, completely inert and physiologically compatible material. Cobalt-chromium alloys similar to those used for orthopedic implants have proved satisfactory.

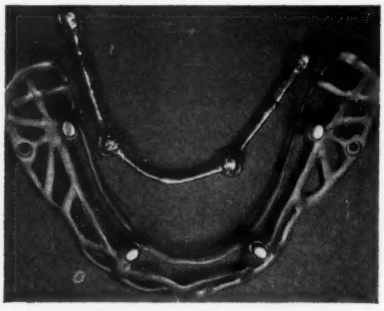

Fig. 7.—Completed implant and superstructure framework. The area between the abutments under incision line is left free of metal. Bulk of metal is kept well to the buccal and labial sides of the residual ridge.

Before the implant is inserted, a temporary superstructure is made which will fit loosely on the implant abutments and occlude with the old upper denture. The temporary superstructure must clear the implant framework by about 4 mm. to allow for the mucoperiosteum over the implant and a little extra space for swelling. It may be lined with a resin of the type that will remain soft for a prolonged period. Teeth, at least the 6 anteriors, are used on the splint for esthetics. With or without molar teeth the acrylic must occlude with the upper posterior teeth.

THE SURGICAL INSERTION

The part of the prosthodontist at the surgical insertion is not as important as at the surgical impression. He checks the fit of the implant against the bone, sug-

gests any slight bone alterations, especially at the grooves, which will allow better seating of the implant, and makes any needed alterations to the metal framework by grinding. Usually the implant will fit the bone like a precision casting, and no alterations to bone or implant are required. After the incision is closed and the temporary superstructure is inserted, the prosthodontist adjusts the occlusion by grinding or, in extreme cases, by the addition of autopolymerizing resin (Fig. 8). He follows the postoperative course, making adjustments to the temporary superstructure if they are required by excessive swelling, and as recommended by the oral surgeon.

As soon as the swelling begins to subside, the soft resin is removed from the temporary superstructure and it is trimmed to the buccolingual width of a finished superstructure. The tissue side, including the part fitting onto the abutments, is relined with autopolymerizing resin. The curing resin must be watched carefully, and the temporary superstructure must be removed from the abutments while the resin is in a rubbery consistency. When completely cured, feather edges which fit into the crevices around the abutments or into the suture line are removed. The temporary superstructure will now serve as a snug-fitting superstructure with which the patient will usually be able to masticate better than he did with his conventional denture until the regular superstrucure can be completed.

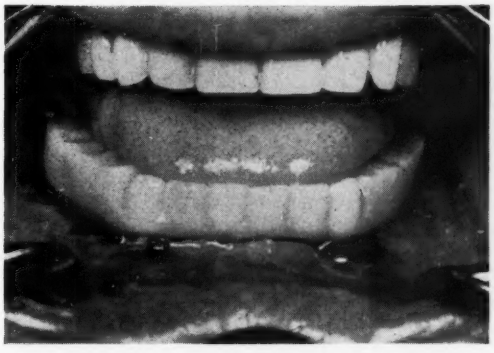

Fig. 8.—Occluded immediate temporary superstructure to stabilize implant, control swelling, aid healing, and act as superstructure for early mastication.

COMPLETING THE SUPERSTRUCTURE

About a month after the insertion of the implant, the patient should be well-healed and ready for the work on the completion of the superstructure to be started. A number of problems not common to conventional prosthodontics are encountered. The following technique, which has been evolved by trial and error, is giving excellent results:

A narrow platform of denture resin is made on the occlusal side of the superstructure framework from the cuspid to molar attachment on each side. The framework is then inserted onto the implant abutments, and the original upper occlusion rim is altered to establish the correct vertical dimension and centric relation. Adequate free-way space is always provided.

An alginate hydrocolloid pickup impression is made over the resin platform and the superstructure framework. If the superstructure frame comes out in the pickup impression, an accurate reproduction of the mucosa under this connecting bar will be obtained. If it stays in the mouth, it will be necessary to trim away enough of the impression material that went under the connector to allow accurate reinsertion of the superstructure into the impression. Later, the resulting stone is trimmed arbitrarily from under the connector on the cast, and the finished superstructure is relined if necessary. After the impression is poured, the hydrocolloid impression is carefully separated without disturbing the resin platform and compound, and the pickup cast is mounted in its correct vertical and centric relations with the original upper cast (Fig. 9). The compound and resin platform is then removed from the superstructure framework, which is not separated from the cast. The lower teeth are set on the superstructure framework, to occlude with the teeth of the original upper wax trial denture, after which the superstructure is processed and finished without a try-in.

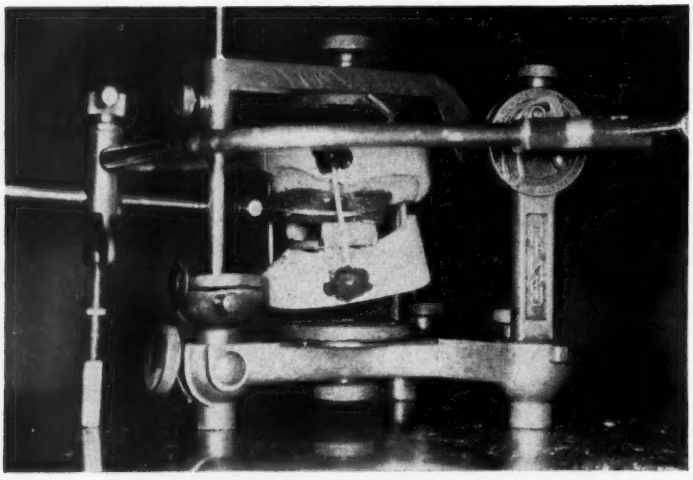

Fig. 9.—Occluded pickup cast ready for completion of the superstructure and upper denture.

An alternate method is to make the pickup impression over the bare superstructure framework. With the superstructure frame in the impression, the inside of the attachments are lubricated with molding clay which has been thinned with glycerin, and the impression is poured in low-fusing metal backed by cast stone. The superstructure framework can then be removed from the metal abutments of the cast for re-establishing the vertical and centric relations, and for the try-in of the waxed-up superstructure. If this method is used, one must be sure that the superstructure is not processed on the low-fusing metal cast as it will melt at even the lowest curing temperatures. The waxed-up superstructure must be invested separately without a cast. After processing, it can be replaced on the metal cast for adjustment of occlusion and elimination of processing errors.

It is considered best to have the superstructure fit the tissue as nearly like a sanitary posterior bridge pontic as esthetics will permit. In fact, 0.5 to 1 mm. of space between the superstructure and the tissue is desirable as there seems to be a tendency for the tissue to thicken somewhat with complete healing.

Acrylic anterior teeth are always used. If the upper denture has good retention and lateral stability, and the lower implant is wide and laterally stable, anatomic acrylic bicuspids and molars are used. If the upper does not afford reasonable lateral stability, flat occlusal porcelain upper posterior teeth are occluded with metal insert lower teeth in order to give maximum efficiency together with reduction of lateral stresses, or acrylic posterior teeth with flat occlusal surfaces may be used.

The finished superstructure is then placed on the abutments in the mouth, and checked by a final try-in with the original upper wax trial denture. Minor adjustments may be made to the occlusion by shifting the upper teeth, after which the upper denture is processed and inserted (Fig. 10). Adjustments and occlusion checks are continued at increasing intervals for three months, at least every six months for two years, and annually thereafter.

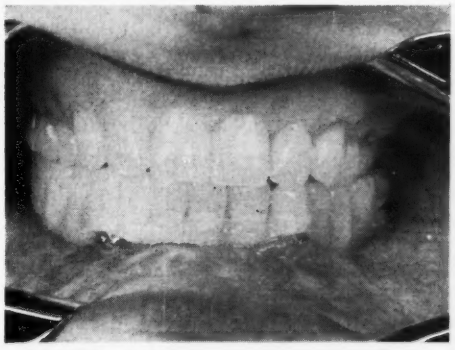

Fig. 10.—Completed superstructure and new maxillary denture. Masticatory efficiency is limited only by upper conventional denture.

PART II. ORAL SURGERY

Raymond L. Kotch

Although the implant denture is basically a prosthodontic appliance, the medicosurgical considerations involved are of sufficient significance to merit the attention of an individual especially trained in the surgical techniques. Because improper surgical technique can result in a failure of the implant as certainly as faulty prosthodontics, this service should be rendered jointly by an experienced prosthodontist and oral surgeon working harmoniously together.

PREOPERATIVE WORK-UP

While the prosthodontist usually sees the patient first and establishes the indications for the implant denture, it is the surgeon who, shortly thereafter, must establish whether any contraindications to this service exist before too much time and effort have been expended, and before the patient's hopes are falsely aroused. A thorough general physical examination to include chest roentgenograms, electrocardiograms, complete blood picture, and a search for debilitating disease must be made by a physician familiar with dental implant problems.[6] Although many patients are likely to be in the older age group, age itself is not a contraindication in the absence of specific findings such as marked arteriosclerosis with or without definite cardiac changes. A patient with diabetes mellitus in any degree, even if controlled, is never a candidate for implantation, and neither is a patient with a history of rheumatic heart disease, nor one with any long-standing, chronic, debilitating disease, such as asthma, renal insufficiency, cardiac, circulatory, or pulmonary disease, nor one with a blood dyscrasia.

All these factors must be carefully evaluated by the oral surgeon in consultation with the cooperating physician before the implant is begun. While not all of the diseases falling into these categories would definitely rule out an implant, their effects upon the body's defense against infection, surgical shock, and upon healing must be known beforehand. The patient must be willing and mentally able to cooperate in the degree necessary because the case can be ruined by his failure to perform as instructed, especially in the immediate postoperative periods. The patient's emotional response to the idea and understanding of the nature of the service will probably have been previously established by the prosthodontist, but it should be re-examined at this time to be absolutely certain that no future possibility of misunderstanding exists.

A thorough examination of the mouth is performed to eliminate the possibility of any local condition or deformity that might threaten the outcome of the case. These would include, besides evidence of nutritional deficiency, infections of the mucosa or bone, and the presence of unusually thin tissue in the implant area. Complete intraoral and extraoral roentgenographic examination of both jaws is required in order to be sure that they are free from disease. Any disease of the bone, whether cystic, neoplastic, or infectious must, of course, be eliminated.

THE FIRST OPERATION. SURGICAL JAW RELATIONS AND SURGICAL IMPRESSION

When it is established that the patient has successfully met these requirements, the prosthodontist proceeds with the construction of impression trays and occlusion rims as described elsewhere. The patient is then prepared for the first operation, establishing the surgical jaw relations and making the surgical impression. An appropriate sedative is administered upon retiring the night before, generally 1½ grains of Seconal. This sedation may be repeated upon arising in the morning, if apprehension is a factor. One hour before the operation, procaine penicillin, 300,000 units, is administered. It is unnecessary to begin chemotherapy any earlier. One-half hour before operation, 1/150 grain of atropine to decrease salivation, and 1 grain of codeine, are given intramuscularly. The use of general anesthesia,

except in rare instances, is ill-advised for procedures such as this, as it represents a greater risk to the patient than the operation itself and offers little that cannot be achieved by the judicious use of local anesthesia and proper sedation.

Bilateral mandibular block anesthesia is performed together with the traditional long buccal injections and, if required, a little infiltration around the arch on the buccal aspect for more effective anesthesia and hemostasis. As soon as anesthesia has taken effect, the abutment locater, previously prepared by the prosthodontist, is placed in the mouth, and the positions of the 4 abutments are marked on the mucosa with a 2 inch indelible pencil through the holes of the locator. The thickness of the mucoperiosteum at the abutment sites is accurately measured with a right-angle probe, and recorded in tenths of a millimeter on the patient's chart and on the master conventional cast. The abutment locator is then reinserted and a No. 6 bur in the contra-angle handpiece is run through the 4 holes in the locator, through the mucoperiosteum, and definite marks drilled into the bone surface. This will furnish a positive location for the abutments and abutment grooves at the exact site determined in the conventional setup.

The incision is now made along the crest of the ridge directly through the line of the proposed abutments. Upon reaching the retromolar pad on each side, the incision curves slightly laterally around this structure and extends to the posterior extent of the pad. The incision should be clean and down to bone in one stroke with little or no retracing to complete its depth. In elevating the mucoperiosteum with a sharp periosteal elevator, it is important to keep it intact with no shredding of the periosteum. The tissue is reflected laterally to expose all of the external oblique ridge, and medial to but not beyond the mylohyoid ridge. In the region of the symphysis, it is elevated on the lingual to include part of the superior genial tubercle which is quite high in these cases, and on the labial aspect it is carried well down to include some of the prominence of the symphysis in the midline. Profuse bleeders are tied with 000 surgical gut suture. The mental foramen and associated structures are carefully located and isolated although their exposure is usually necessary, and it is advantageous to have them show in the impression (Fig. 11).

The bony surface is then examined by both surgeon and prosthodontist. Keeping in mind the desirability of an intact bone cortex to avoid osteitis and to preserve the main weight-bearing organ of the implant system, modifications to the bone surface are performed only where they are essential to the implant construction by means of bone drills, rongeurs, and files. If a portion of the alveolar ridge remains, as usually occurs in the cuspid region, it is currently considered advisable to cut abutment grooves to countersink the primary cross struts flush with the bone surface as they approach the abutments, thereby making it easier for the mucoperiosteum to grow snugly around the neck of the abutments. Grooves should not be made for the molar abutments if the alveolar ridge is resorbed because of the proximity of the mandibular canal to the surface. These grooves are located at the exact sites of the bur marks in the bone surface which were made previously through the holes in the abutment locator. They are prepared to a depth of 2 mm. and to a width nearly as great as the abutment themselves.

The left and right lingual flaps are then loosely sutured together, across the mouth over and under the tongue, to retract them from the mandible. The buccal flaps may be similarly sutured to the cheeks to expose the mandible fully, but usually they will retract adequately when the cheeks are retracted in making the impression. If it will aid in securing a good impression, a labial vertical incision may be made,

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 11.—Surgical reflection of mucoperiosteum and preparation of cuspid grooves prior to establishing surgical jaw relations and making surgical impression.

Fig. 12.—Surgical insertion. Note the excellent fit of the implant casting, and how bone rather than metal will be under closed incision line.

Fig. 13.—Finished suturing. If primary healing is to be obtained, adequate and properly placed sutures are of extreme importance.

but this should be avoided if possible. During the entire operation, the exposed bone and tissue are kept moist by frequently spraying with warm saline solution. After the prosthodontist has finished recording the surgical jaw relations and making the bone impression, rather deeply placed continuous lock 000 silk suturing is employed. At this stage, the suturing is not quite as vital as at the second operation for the insertion of the implant.

After the old conventional denture has been inserted as a surgical splint, or adequate gauze packing placed in the mouth, an extraoral elastic bandage is applied around the chin and head to help combat swelling and maintain occlusion. Postoperative care includes a liquid diet, continuous ice packs to the face, 1 grain of codeine intramuscularly as required for pain, and bed rest. The diet is modified as tolerated and after seventy-two hours, the bandage is removed and ice packs are discontinued. Chemotherapy is continued for a minimum of seventy-two hours. The sutures are allowed to remain as long as they are beneficial, usually being removed about the fifth to seventh day, after which postoperative treatments are continued as indicated. Hygienic measures are emphasized to the patient during this period, as well as a twice daily spraying or rinsing with a weak antiseptic solution. The patient is observed closely during the healing period following the surgical impression for possible hints suggesting an improvement in technique that might produce a more rapid and complete primary healing following the more critical insertion of the implant.

THE SECOND OPERATION. SURGICAL INSERTION

The second operation, for the insertion of the implant, usually takes place from three to six weeks after the surgical impression, depending in part upon the progress of the laboratory work and in part upon the rapidity of healing. Preoperative management is identical with the first operation. The incision is made along or close to the same line as before, keeping it exactly in the middle of the open metal-free part of the implant. The mucoperiosteal flap is carefully re-elevated to the minimum extent necessary for inserting the implant. The casting is seated upon the mandible and checked for proper fit (Fig. 12). Modifications, when necessary, may be made to the metal framework, the bone surface, or both to ensure the best possible fit.

If screws are used for fixation, special 5 to 7 mm. long screws are required. Small bone drills or burs are used to start the holes through the cortical plate to receive the screws which are then snugly but lightly seated with a convenient screwdriver easily made from an operative hand instrument. If the screw sites are properly located to the buccal of the external oblique ridge, there will be no danger of the screws entering the mandibular canal. Occasionally, circumferential wiring may be preferred as the means of fixation. If so, these are inserted, one on each side between the anterior and posterior abutments, using the method of insertion most familiar to the surgeon. Intraosseous wiring, although generally successful in bone surgery, is best avoided as it presents an unnecessary interruption of bone continuity. Whatever the means of mechanical fixation, it should be understood that it has no function after the first few months. Once the fibers running from the periosteum to the bone have been reconstituted, mechanical fixation is superfluous. This is the reason it is so important to have an intact mucoperiosteal flap, thereby assuring that the periosteum lies over the implant. Upon reattaching to bone, this layer firmly binds the implant to the bone. In fact, if the implant is wide and firm with abutment grooves, and if it is properly stabilized by

an immediate occluded temporary superstructure, mechanical fixation by screws or wires is probably unnecessary, although it is a desirable safety precaution to prevent displacement during the first few weeks.

Suturing following the surgical insertion is of the greatest significance, in order to avoid excessive breakdown of the suture line and exposure of the implant. In many patients, there is found some defect in the postoperative healing of the sutureline, especially anteriorly, but these usually granulate in and heal uneventfully. Nevertheless, every attempt is made to eliminate or minimize a breakdown. Interrupted vertical mattress sutures, 00 silk, are deeply placed mesially and distally to each abutment. Vertical mattress sutures are preferred because they evert the tissues at the suture line, thereby bringing more raw surface into contact and increasing the chances for a prompt healing by primary intention. Interrupted sutures, 000 silk, are placed as required between the abutments. Interrupted sutures can be spaced wider than a continuous suture, thereby resulting in fewer tissue punctures. Further, in case a thread tears out or breaks, the entire incision is not jeopardized. Only as many sutures are used as are needed to hold the edges in apposition, which varies from patient to patient. Additional sutures serve no purpose and merely act as irritants to delay healing. If there is sufficient tissue to permit, wide tension sutures, 0 silk, may be placed, one on each side and one in the anterior region, to relieve the tension on the suture line. These are best inserted, but not tied, prior to the suturing. Following completion of the marginal suturing, the tension sutures are tightened and tied (Fig. 13).

The immediate temporary superstructure splint is now inserted, relieved to adequately clear tissue and allow for moderate swelling, and then permitted to occlude with the opposing denture. The elastic bandage around the head and chin should have sufficient tension to keep the temporary superstructure seated on the implant abutments and in occlusion until the swelling begins to subside and the occlusal support can be maintained by the patient.

POSTOPERATIVE FOLLOW-UP

Postoperative care is the same as after the first operation with ice packs, thorough mouth hygiene, and adequate bed rest. The sutures are allowed to remain as long as they are beneficial and then removed individually after five to seven days. Chemotherapy is continued for one week. Should any local breakdown of the suture line occur, it will usually granulate in and heal without intervention even though metal may be exposed. Small areas will usually close in one to two months, while larger areas may require a year or more. No treatment is given other than keeping it clean and being sure that the superstructure does not invade the area. The use of surgery or caustics is generally unsuccessful and may do harm by destroying urgently needed tissue. Other complications are treated as dictated by sound surgical principles. The patient is checked regularly by the oral surgeon for at least two months and until the healing is complete. As early as possible, the patient is instructed in brushing the implant abutments and the surrounding tissue with a soft toothbrush and in the use of dental floss around the abutments.

Shortly after the insertion, routine extraoral and intraoral roentgenograms of the mandible with the implant in place are made. These are repeated in two months, and six months to check upon the bone and detect any degenerative changes early. These patients should be re-examined annually or semiannually for an indefinite period of time in view of the relatively little knowledge regarding the future of implants. Within four or five weeks after the surgical insertion, the patient usually will be ready for the prosthodontist to begin work to complete the regular superstructure.

CONCLUSION

Although the construction and insertion of a successful mandibular implant denture is not formidably difficult in the hands of competent prosthodontists and oral surgeons familiar with implant problems, it is filled with many hazards for beginners in the implant field. The shortcomings most common to beginners are:

1. Insufficient buccal and labial reflection of the mucoperiosteum.
2. An inaccurate or insufficient impression of the bone surface.
3. Too much metal over the ridge and under the incision line, or the periphery too thick on the lingual where the tissue is usually thin.
4. A thin and flexible implant rather than one which is strong and rigid.
5. Inadequate depth and extent to the suturing, too early removal of the sutures, and inadequate splinting, bandaging, and general postoperative care, all of which leads to a breakdown in the suture line, subsequent healing by granulation with a good chance for development of undesirable exposure of the implant framework in the suture line.
6. Insufficient attention to such prosthodontic essentials as adequate free-way space and smoothly balanced occlusion, lack of which will inevitably traumatize an implant denture and produce bone resorption.

From the patient's standpoint, present-day mandibular implant dentures have so much greater efficiency and comfort than conventional dentures[7] that patients have difficulty finding words to make the comparison and express their enthusiasm. This is because, in the implant denture, the stresses of mastication are borne directly on the mandibular bone, and no pressures are felt on the underlying mucosa. With patient attitude and enthusiasm such as this, a steadily increasing patient demand for implant denture service can be expected.

The number of mandibular implant dentures that have been in place for five years, and the immense advancement in design, technique, and knowledge of the last two years, has lifted the mandibular implant denture out of its experimental phase when it is used by experienced hands. It is finding a definite place in modern dentistry for the patient who cannot physiologically or psychologically adjust to conventional dentures. With a continued steady advance in implant knowledge, a simplification and standardization of techniques, and an increase in the number of qualified implant prosthodontists and oral surgeons, it is inevitable that the near future will see a steady growth of the implant denture field to serve more and more patients who are dissatisfied with the limitations of conventional dentures.

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HISTOPATHOLOGIC FINDINGS ON VITALLIUM IMPLANTS IN DOGS

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THE INSERTION of inert compounds into the body is as ancient as mankind. Early reports date back to 1565 when Petronius devised a gold plate for the repair of a cleft palate. In 1725, Lapeyode and Liere were among the first to use metal wire in fracture cases. Then silver and aluminum were tried in surgery. However, most of the metals used proved unsatisfactory inasmuch as they caused irritation or destruction of the bone and adjacent tissues due to their electrolytic activity in body fluids. It was not until 1936 that Venable, Stuck, and Beach, in conducting experiments on the electrolysis of different metals, demonstrated that Vitallium was electropassive in body fluids, and consequently was inert and non-irritating to human tissue.

Vitallium is a trade name for an alloy developed by Austenal Laboratories Inc. in 1929. It is composed of cobalt 65 per cent, chromium 30 per cent, molybdenum 5 per cent. It is not a stainless steel. In 1949, Goldberg and Gershkoff[1,2] published reports on successful Vitallium implant dentures. Their method was originally a one-stage procedure. It consisted of the use of a roentgenographic template in such a manner that intraoral findings could be more or less accurately transferred to the cast, and the cast prepared to resemble the bony ridge of the mandible. This method was further developed and modified by them as well as by Ogus,[3] Berman,[4] Lew,[5] and others, with the final evolvement of the two-stage technique. With the two-stage procedure, a direct impression of the exposed bone is obtained. The casting is then designed on a cast made from this impression. The implant is cast, sandblasted, and then inserted at the second operation. Although this method is possibly more traumatic than the one-stage procedure, it is far more accurate.

These respective techniques of Vitallium implantations have met with mixed response among the members of the dental profession. To explore certain of the controversial aspects of Vitallium implants, it was decided to conduct a series of experiments on dogs, and to study the histopathologic sections after the animals were sacrificed. Thus some objective evidence would be gained.

TECHNIQUE

Under general anesthesia (used only because we were dealing with animals), a clean straight incision was made across the ridge between two points. The incision was carried slightly off to the buccal side of the crest of the ridge. The mucoperiosteal flap was gently reflected. Sutures were placed at the edges of the

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flap for better retraction. The sharp edges of the alveolar crest were removed with either rongeurs or bone files. The exposed bone was then washed with a saline solution, and an impression was made with a low-fusing modeling compound. The compound was pressed firmly into place, chilled, and removed. Then the inside of the impression was covered except the root part which enters the socket[s] in certain cases) with a zinc oxide-eugenol paste impression material and the entire impression was reseated over the bone area. Thus an accurate impression with all minute details of the osseous bed was obtained. The wound and bone were cleansed with saline solution and dusted with Terramycin powder. The wound lips were approximated loosely with interrupted sutures in order to permit granulation in the loose spaces and to make it possible to approximate the wound edges tightly when the casting would be inserted under the mucoperiosteum at the second stage.

Fig. 1.

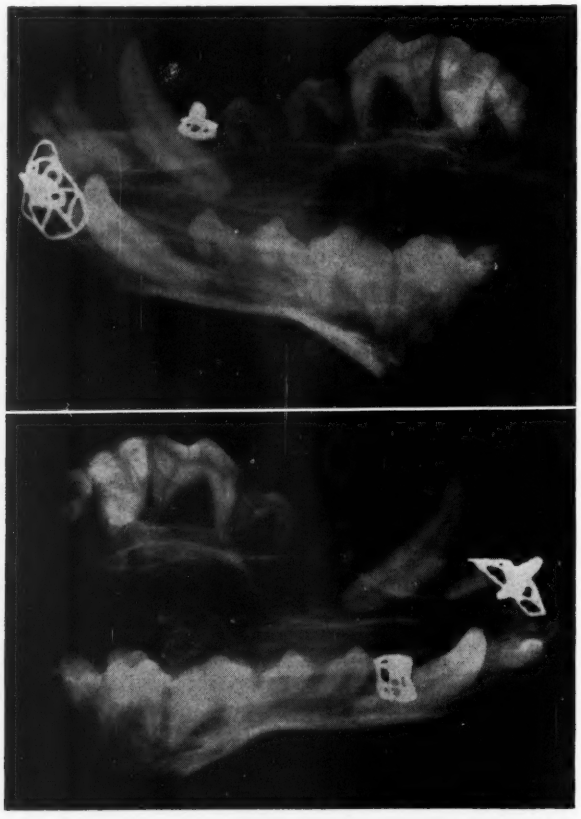

Fig. 2.

Fig. 1.—A roentgenogram of the implant-inplant on the right side and the implant only on the left side.

Fig. 2.—A roentgenogram showing the Vitallium meshwork of the implant.

The implants or implant-inplants were designed and waxed on the cast and the castings were made. Care was taken that (a) the implant meshwork was

1 mm. in thickness or less; (b) the edges of the implant tapered to a feather margin; (c) when the implant-inplant combination was used (Figs. 1 and 2), the root part was shaped in the form of a wire loop. The latter structure was designed by us for the purpose of insertion into an alveolar socket after tooth extraction. Thus newly formed bone tissue was able to grow through the loop and firmly entrench the implant-inplant. The other implants had no roots and were shaped in the form of a saddle. By this means, the necessity for screws, pins, and other appliances was eliminated. Another innovation was the design of the abutments on which the superstructure or dentures would be superimposed. We

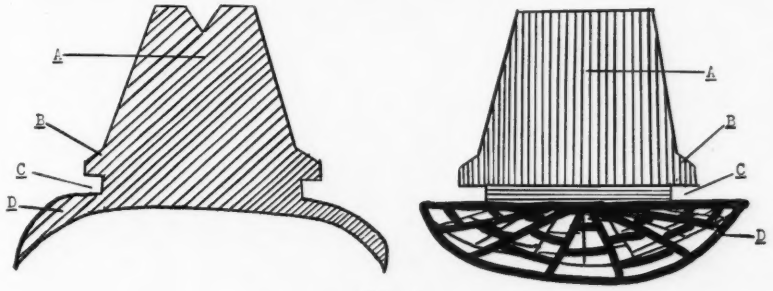

Fig. 3.

Fig. 3.—Implant design. *A*, abutment. *B*, Shoulder preparation (like for jacket crown). *C*, Gingival tissue. *D*, Implant meshwork.

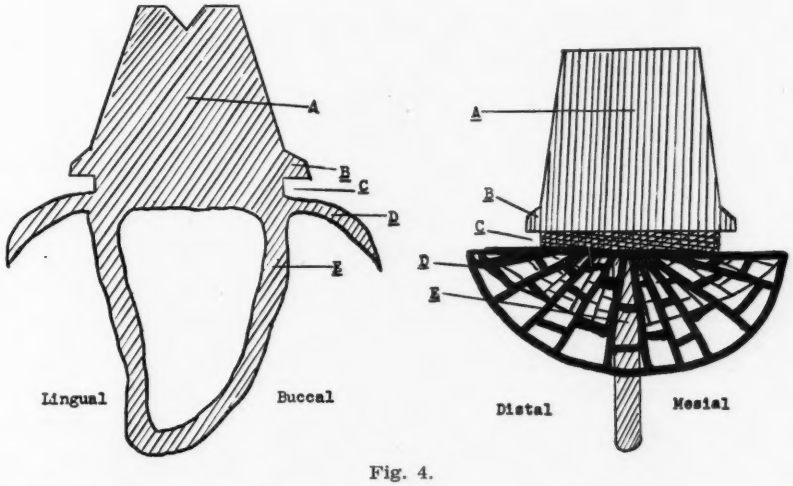

Fig. 4.

Fig. 4.—Implant-inplant design. *A*, Abutment. *B*, Shoulder preparation (like for jacket-crown). *C*, Gingival tissue. *D*, Implant meshwork. *E*, Root part.

wanted to avoid overextended platforms, for these may cause impingement of the gingival tissue. Therefore, a shoulder was prepared on the abutment. This was similar to the one prepared for a jacket crown with the sole difference that this shoulder was not under the gum line (Figs. 3, 4, 5, and 6). The occlusal part of the abutment was shaped into a slot. This helped to stabilize the crown part of the superstructure. The castings were sandblasted only.

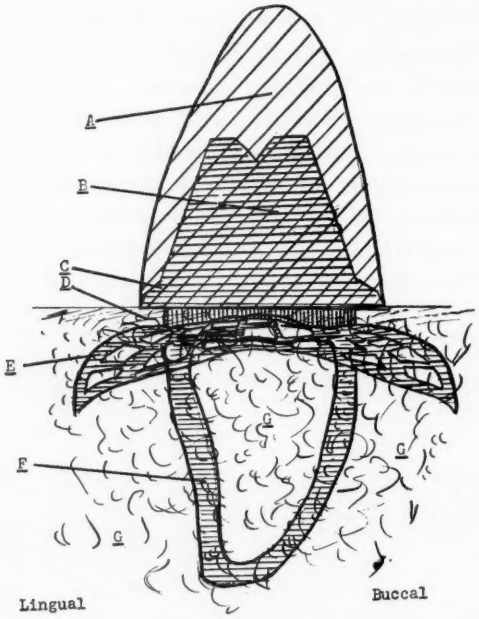

Fig. 5.—Implant-inplant design. *A*, Crown part of superstructure. *B*, Abutment. *C*, Shoulder preparation (like for jacket-crown). *D*, Gingival tissue. *E*, Implant meshwork. F, Root part. *G*, Bone.

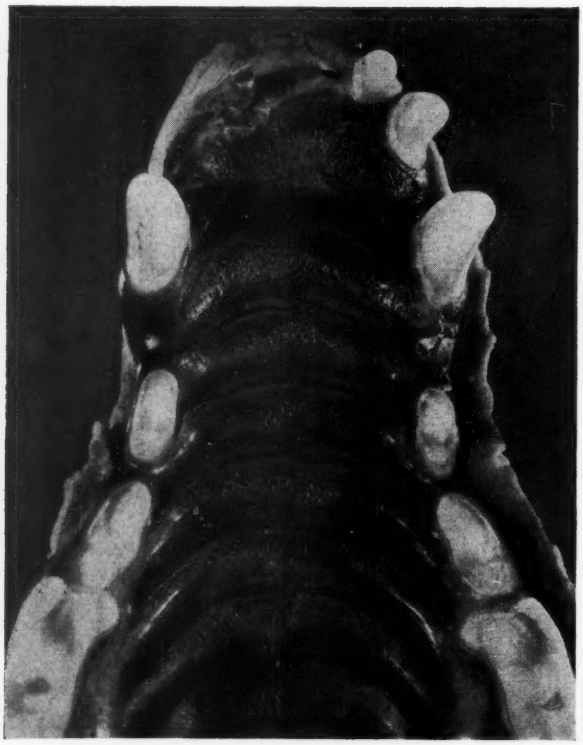

Fig. 6.—The implant and implant-inplant have been inserted. Note the slot in the abutment part.

Fig. 7.

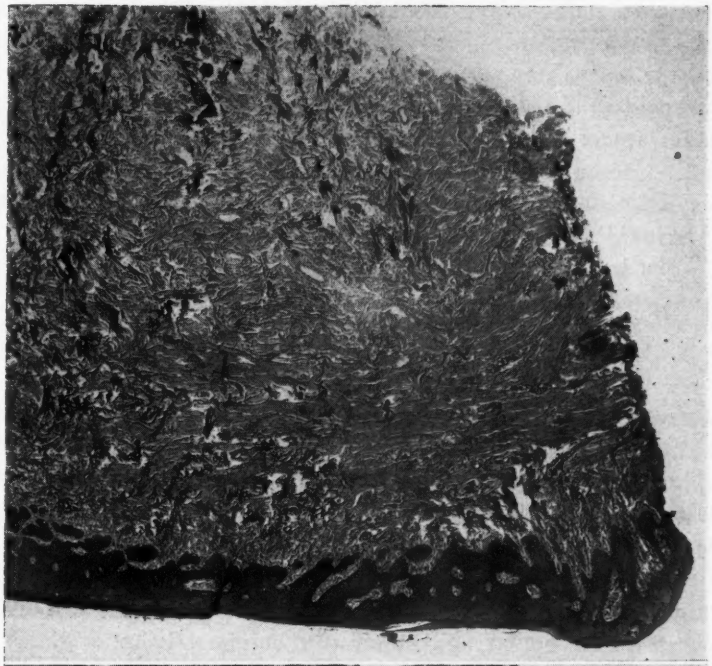

Fig. 8.

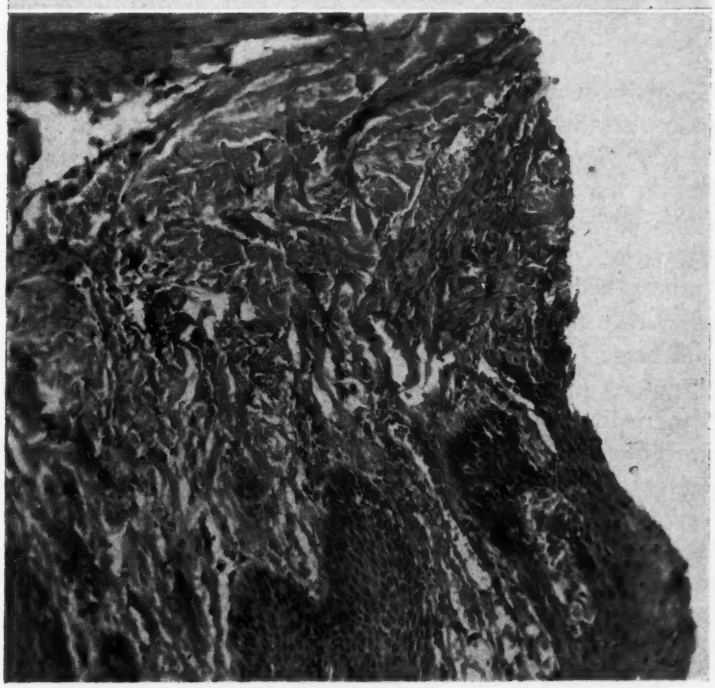

Fig. 7.—A low-power photomicrograph of a segment of the gingival margin adjacent to the Vitallium abutment showing minimal tissue reaction. ×40.

Fig. 8.—A high-power photomicrograph of a minute area of granulomatous reaction beneath squamous epithelium. There is no evidence of foreign body reaction. ×175.

Ten days later, the second-stage procedure was carried out. Following the line of the original incision, the tissue was reflected in the same manner as described in the first operation. The autoclaved implants or implant-inplants were inserted, and the entire area was dusted again with Terramycin powder. Special attention was paid to the coaptation of the edges of the wound, especially around the abutments. Interrupted sutures were used. Edema was controlled by the application of Hydrocortone Acetate 2.5 per cent. The postoperative care consisted of antibiotics for one week, narcotics for pain, and a liquid diet. After about three weeks, the animals were allowed normal food. The sutures were removed in seven days. The animals were sacrificed three months after the implants and implants-inplants were inserted.

HISTOPATHOLOGIC STUDIES*

Our studies tended to confirm the lack of tissue reaction to Vitallium. Sections of gingival tissue were taken immediately at the point of implantation (Figs. 7 and 8). A microscopic study of these sections was made. Squamous epithelium covered the one side near the abutment with minimal parakeratosis and acanthosis. A scant amount of hyperemic granulation tissue was present. The corium was composed of dense collagenous bands containing a few capillaries. Evidence of an active inflammatory process was absent. Further sections taken at a distance from the abutment revealed similar epithelium with minimal lymphocytic and plasma-cell infiltration. Hence, it is rather obvious that there was no reaction to the Vitallium implant.

Because of the exposure of the dental implant to the outside, and the constant contact with salivary enzymes, food particles and bacteria, there is a possibility of seepage through a crevice around the projecting abutment. This was not confirmed in our studies. The tissue around the abutment was firmly attached, and no definite pocket formation or foreign body accumulation was demonstrable microscopically. This reaffirms the clinical observations of Bodine and Kotch[6] and others that no pathways into the body seem to exist.

We found that the retentive medium for the implant were the periosteal fibers and not bone. It was found physically impossible to remove the implants with normal pulling pressure. Hence in preparing microscopic sections, decalcification was carried out in order to remove the Vitallium mesh. The microscopic sections were covered with squamous epithelium on their outer aspects with a moderate degree of acanthosis and parakeratosis. The basal layers were intact, and there was no evidence of atypical epithelium proliferation. The upper two-thirds of the section was represented by collagenous connective tissue. The lower third of the corium contained large and small spaces from which the wire mesh had been removed. At the edge of these spaces, there was evidence of large irregular blue-staining calcific masses associated with small zones of new fibroblastic proliferation. Numerous dilated capillaries dotted the edges of the fibroblastic proliferation. In patchy areas adjacent to the calcium deposits, there were

*The microscopic sections were interpreted by Dr. Lawrence Wm. Gardner, Chief Pathologist, Mt. Carmel Mercy Hospital.

scant infiltrates of plasma cells and lymphocytes. In the deeper portions of the corium, there were trabeculae of osseus tissue associated with marrow and showing no significant histopathologic changes. This microscopic study negates the necessity of placing implants into the bone by means of screws or pins as the basic strength of the implant is the periosteal fibers that grow through the meshwork of the implant into the cortical bone. The danger of entering areas like the maxillary sinus or mandibular canal by means of screws is eliminated. We feel that this reaffirms the investigations of Weinberg[7] and others.

CONCLUSIONS

So far we have limited our work to dogs and to partial implants only. We were most interested in the histopathologic studies of the periosteal fibers growing through the meshwork of the implant and the gingival tissue around the abutment(s). This is the area questioned most in the minds of many investigators.

From these limited experiments, we believe that the work on Vitallium implants appears promising, and that they will find a definite place in dental surgery. However, it is obvious that it is yet too early to make any definite commitments. This work is being continued on animals and human beings, and the findings will be reported in other articles.

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FUNDAMENTAL PRINCIPLES OF OROFACIAL PROSTHETIC THERAPY IN CONGENITAL CLEFT PALATE

Part I. Diagnosis and Treatment Planning*

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DIAGNOSIS AND TREATMENT PLANNING

INCIDENCE, MEDICODENTAL IMPORTANCE

THE RELATIVELY high incidence of congenital cleft palate, which varies according to different authors from about 1 in 700 to 1 in 1,000 births, presents a challenging problem in rehabilitation[1] to the medical and dental professions. Since rehabilitation raises medical, surgical, dental, psychologic, phonetic, and social problems, it should be brought about by the close teamwork of well-trained specialists in their respective fields.[2] Cleft palate clinics have been set up in several states[1,2] and have contributed to the rehabilitation of the orofacial cripple.

The etiology of congenital cleft palate is still obscure. There is evidence of hereditary factors,[3] and nutritional deficiencies have been mentioned, but experimental evidence is scarce. The observations of Straus[4] in animals, and the experimental work of Giroud and Boisselot[5] illustrate the thesis of its nutritional deficiencies. Mechanical causes, such as pressure on the palatine processes during fetal life, as well as toxins, alcohol, and drugs have been suggested.[6]

The medical importance of cleft lip and cleft palate is striking if only the nutritional deficiencies which may result from feeding difficulties are considered; these deficiencies increase the patient's susceptibility to upper respiratory infections and lower physical resistance.[2] In early childhood, frailness, high susceptibility to childhood diseases, slow growth and development, chronic rhinitis, and possible otitis media are all problems to be considered.

Lip surgery is generally performed during the first month of life. Later in childhood, speech and psychologic problems must be solved. Cosmetic factors begin to have their importance. The dental aspects of this condition are striking: The deformity results in inadequate mastication, deglutition, and speech. Introduction of foreign bodies and liquids into the nasal cavity is irritating and predisposes to infection. Malocclusion develops early. Disfigurement and speech abnormalities follow.[6-9] The mental and moral effects of the deformity lead sometimes to negli-

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gence of oral hygiene which is followed by a high caries incidence.[3] Speech evaluation and therapy are important and should be instituted at an early date.

A speech therapist will be able to evaluate the patient functionally. The complete care of the patient requires the services of the pediatrician, plastic surgeon, psychiatrist, psychologist, otorhinolaryngologist, orthodontist, pedodontist, prosthodontist, and oral surgeon, as well as the speech therapist.

SURGICAL PATHOLOGY

The congenital malformations occur between the sixth and eleventh week in utero. The premaxilla and the palatine processes unite during the eighth week, and the soft palate unites during the eleventh week.

According to Veau,[10] the following anatomic defects of the palate may be found (Figs. 1, 2, and 3):

1. Cleft of the soft palate	20.8%
2. Cleft of the soft and hard palate	30.8%
3. Cleft of the soft and hard palate, and unilateral premaxillary cleft	38.8%
4. Cleft of the soft and hard palate, and bilateral premaxillary cleft.	9.6%

Other classifications have been given by Ivy,[11] Dorrance,[12] and Brophy.[13] Many subdivisions have been described. The lip alone is involved in about 20 per cent to 25 per cent of the patients.[2]

SECONDARY DEFORMITIES

1. Retrusion of the Upper Lip.—This is usually due to the lack of bony support, absence of the upper anterior teeth, and the presence of a premaxillary cleft. Irregularity of the lower border of the lip is observed in operated cases.[14]

2. Deformities of the Nose.—Distortion, flatness of the nostrils on the side of the defect, deviation of the nose, and a broad flat tip are not unusual.[14]

3. Malocclusion.—Early operation of the lip may leave some stiffness which interferes with the anterior development of the dental arch. Growth and development in nonoperated cleft palate patients tend to spread the underdeveloped palatal processes, and as a result the width of the cleft increases.[9,15] The pathogenesis of malocclusion may be explained by the inward pressure of the buccinator muscles on the dental arch when the palatal suture and part of the bony palate are missing. The lateral development of the arch in the premolar region is subnormal, the teeth are in a lingual position in relation to the lower arch. The pressure of the tongue and the mandible against the inclined occlusal planes of the upper teeth tend to spread the maxillary bones further apart.[9,15]

Clefts of the soft palate do not affect the occlusion, and in the same degree the development of the upper arch remains relatively normal.[15] Extreme cases result in a completely crippled palate with gross distortion of the upper dental arch, missing teeth, impacted teeth, and collapse of the alveolar bone.[1,16]

4. Postoperative Patients With Surgical Anatomic Failure.—Crippling deformities are mainly observed in the postsurgical patients. A combination of all

Fig. 1.

Fig. 2.

Fig. 3.

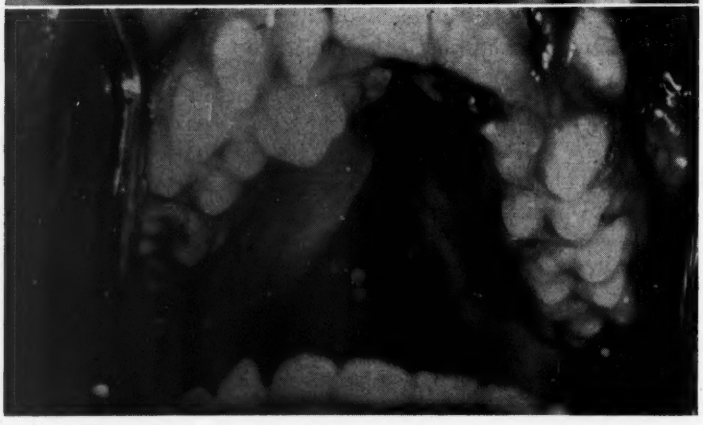


Fig. 1.—Cleft of the soft palate.
Fig. 2.—Cleft of the soft and hard palate.
Fig. 3.—Cleft of the soft and hard palate with a bilateral premaxillary cleft.

previously mentioned conditions are seen. Specifically, we may observe: (1) secondary perforations of the soft palate, (2) a well-repaired soft palate, but a remaining cleft of the hard palate, (3) a remaining premaxillary cleft with a well-repaired soft and hard palate, (4) scar tissue formation and fibrous contraction resulting in rigidity of the velar sphincter, and (5) grossly mutilated palates (Figs. 4 and 5).

The number of teeth present in the arch and their condition have to be considered. We have, therefore, the completely edentulous patient, the partially edentulous patient, and the patient with a full complement of teeth.

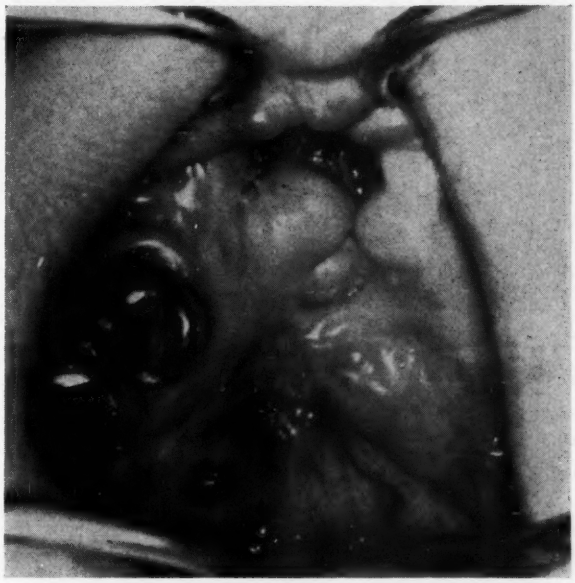


Fig. 4.—Cleft of the soft and hard palate with a premaxillary cleft: postoperative failure, scar tissue formation, shortened velum, and remaining anterior alveolar cleft.

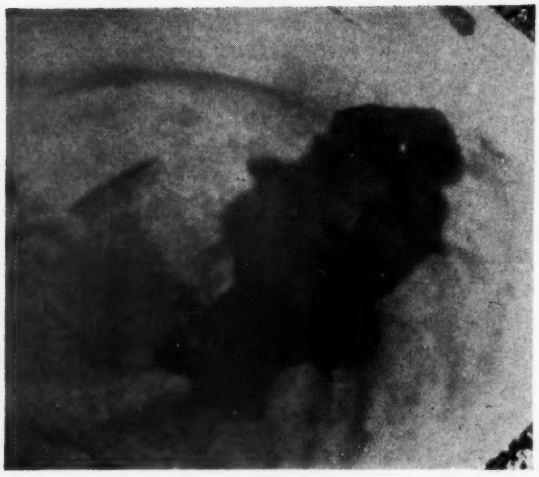
It is of interest to review briefly the phonetic results obtained by the surgical closure of the cleft because they determine to some extent the indications of prosthetic treatment.

Though surgery improves appearance, mastication, and deglutition immediately, speech is not always favorably affected. The purpose of the closure of the palate is "to give back to the patient the means to speak correctly" as Veau[10] stressed in his work. Axhausen[17] obtains successful primary closure in 98 per cent of his patients (300 patients), Veau, 82.8 per cent in 500 patients. Statistical data concerning phonetic results are scarce. Axhausen,[17] Vaughan,[18] Veau[10] and Pichler and Trauner[19] have given thorough statistical evaluations of their cases considering the phonetic result obtained by their operations. To evaluate phonetic results objectively, many factors have to be considered, and the criteria of the different authors differ in the detail.

A comparative study of the available data points out the fact that patients operated on after the age of 12 years presented about 50 per cent of phonetic

success; that is, no noticeable speech defect. The other 50 per cent presented average or strong nasality (rhinolalia). The best phonetic results were obtained with early operations in the 2- to 3-year age group; Axhausen[17] obtained 92.4 per cent success (normal speech); Trauner[19] achieved 97.5 per cent success in his last forty-one operations. The average results of Axhausen, Veau, Trauner, and Vaughan, with all the different evaluation criteria of the phonetic result taken

A.



B.

Fig. 5.—*A*, Remaining oronasal communication after surgery for congenital cleft palate repair in an edentulous patient. *B*, Latex plug made on the model to be inserted in the anterior cleft before taking the impression for the full upper denture.

into consideration, vary from 70 per cent to 80 per cent success. They include children up to the age of 12 years, with the highest number of patients in the 2- to 6-year age group. Those patients have a normal speech or very slight phonetic deficiencies. This very cursory evaluation of phonetic results points out the fact that about 50 per cent of the patients, who underwent later operations, need some kind of a speech aid, and that about 10 to 25 per cent of early operated patients may require prosthetic treatment.

INDICATIONS FOR PROSTHETIC THERAPY

1. PRE SURGICAL PROSTHESIS

Corrective therapy for the cleft palate patient should be instituted as early as possible in certain cases. The newborn child is very susceptible to respiratory infections; adequate feeding is essential to maintain normal growth and development. Temporary measures may be used to close off the nasopharynx from the oral cavity partially. A simple appliance may be constructed for feeding purposes, if available special nipples are not satisfactory. The closing off of the defect insures better feeding, decreases irritation of the nasopharynx, and promotes better health (Figs. 6, 7, 8, and 9).

Fig. 6.—Presurgical prosthesis; indications for the construction of a feeding aid in newborn infants, Class III cleft. (Courtesy of Dr. Martin Siegel.)

In early childhood, prevention of faulty speech habits is stressed by Harkins,[16] and he advocates the use of a simple speech aid retained by atmospheric pressure before the eruption of the deciduous teeth is complete. Cooperation of the little patient is required in order to construct such an appliance, and this is difficult to achieve before the age of 4 years. After the eruption of the deciduous teeth, an appliance may be constructed with the aid of the orthodontist, who at that time will often start preventive orthodontic therapy. After 6 years of age, if plastic repair is further delayed, orthodontic, operative, periodontal, speech therapy, and prosthetic treatment must go hand in hand. The earlier a speech appliance is inserted, the better the child will get used to it. Adaptation is best in childhood. Self-pity, hypersensitivity and self-consciousness will be decreased. The patient is able to adapt himself more readily to his handicap and to society with a speech aid. Ottolengui[20] stressed as early as 1913 the need for early prosthetic treatment.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 7.—Cast of the Class III cleft seen in Fig. 6. (Courtesy of Dr. Martin Siegel.)
Fig. 8.—Obturator constructed of a fast curing acrylic resin to act as a feeding aid.
Fig. 9.—The tongue side of the obturator in Fig. 8.

2. SURGICAL PROSTHESIS

Aids for surgical procedures may be constructed for children as well as for adults. Surgical stents and splints are used in cleft palate and cleft lip surgery (Fig. 10). Two types of appliances may be considered:

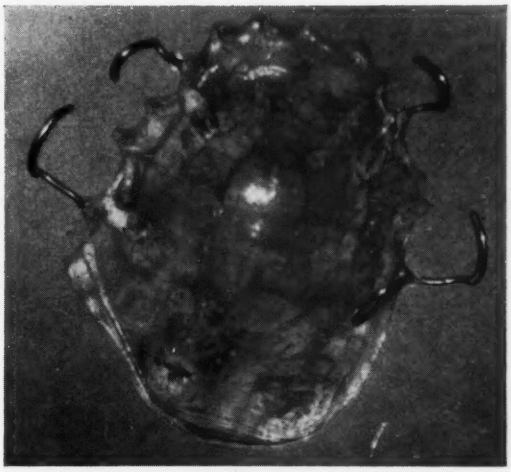
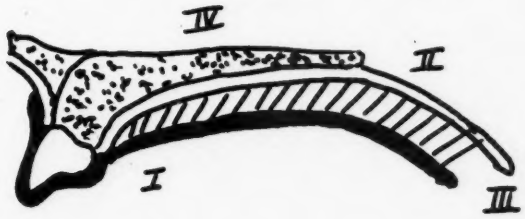


Fig. 10.—A surgical splint for the protection of the palatine flaps and the suture line. The appliance also molds the flaps against the bony processes of the palate.

Fig. 11.



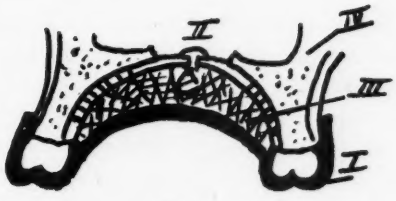


Fig. 12.

Fig. 11.—Sagittal diagram of a surgical splint *I*, splint in clear acrylic or celluloid; *II*, suture line and flaps; *III*, surgical pack (petrolatum or dry gauze); *IV*, palatine bone.

Fig. 12.—Frontal diagram of a surgical splint: *I*, splint in clear acrylic or celluloid; *II*, suture line and flaps; *III*, surgical pack (petrolatum or dry gauze); *IV*, palatine bone.

1. Surgical splints to protect the palatal flaps and the suture line, to prevent collapse of the vault and possible bacterial contamination. Axhausen[17] and Schmuziger[21] advocate a celluloid splint which fits over the deciduous teeth, which is relieved to prevent pressure on the suture line, provides space for the gauze packing, and is adjustable as to length and contour by simply adding gutta-percha or modeling compound that will support and mold the soft palate. The same type of splint may be constructed in clear acrylic. Axhausen has used it to advantage in several hundred cases of cleft palate repair. Gross[22] advocates a modified splint to prevent the patient from disturbing the suture line by using cross wires which keep the tongue and the fingers of the patient away from the wound.

2. Surgical stents for deepening and repairing the labial alveolar sulcus with a skin graft covering the alveolar ridge and canine fossa may be used. Kazanjian[14] advocates such appliances for plastic reconstruction procedures of the lip and nose where the bony support has been lost. The appliance may be stabilized and retained by clasps or orthodontic bands (Figs. 11 and 12). In the latter, a sliding device is provided for the insertion of the stent section of the appliance. The scaffolding mold is retained by the framework of the partial denture when a removable appliance is constructed. An obturator bulb may be also adapted to support and immobilize a skin graft in the surgically repaired defect.

3. INTERMEDIATE PROSTHESIS

The need for prosthetic treatment is important in this group of patients. In this category fall those appliances that are used to close off the defect until a second-stage surgical operation is indicated. For instance, a primary closure of a cleft of the soft palate is performed and the repair of the hard palate cleft is postponed until later. In this case, an obturator is constructed for the interim period to close the defect of the hard palate.

4. POSTSURGICAL PROSTHESIS

This group represents the greatest number of patients. Indications for prosthetic treatment include the age of the patient, the health, the surgical risk, the extent of the cleft, or psychologic reasons contraindicating surgery. The patient who wishes a painless and rapid result, and refuses surgery also belongs in this class. The other chief indication for prosthesis is the patient for whom surgery has failed. The postoperative surgical failure is difficult to handle. Surgical failures may be divided into: (a) anatomic failures (too short a soft palate, atrophy of the velar muscles, and remaining openings in the hard palate and/or soft palate), and (b) physiologic failures (in those cases, the hard and soft palate is generally well closed, but the articulation of consonants is impaired and a strong rhinolalia remains). The velopharyngeal sphincter is rigid and has no functional value. The physiologic failure is best determined by the speech therapist.

OPTIMUM TIME FOR PROSTHETIC THERAPY

Prevention of undesirable habits in speech and subsequent psychologic disturbances are the primary aims of speech therapy. The first three years of life are not too important in the formation of speech. Rehabilitation of the palate may be delayed during those years.[24] An appliance is only necessary if the infant has a definite feeding problem. Early surgery in order to prevent speech defects during the first two years of life is also to be questioned.[1] At about 3 years of age, when the deciduous teeth have erupted and the child starts to learn the pronunciation of consonants, constructing the first speech aid may be considered.[16, 25] Generally, an intermediate appliance is used until the age of 4 to 6, the optimum age for the surgical repair of the palate.[2] Growth and development research have shown that the growth of the maxilla is maximum during the first five years of life. At the age of 4, the patient's situation should be re-evaluated to determine if orthodontic treatment, combined with prosthetic and speech therapy, is indicated or if surgery is best for the child.

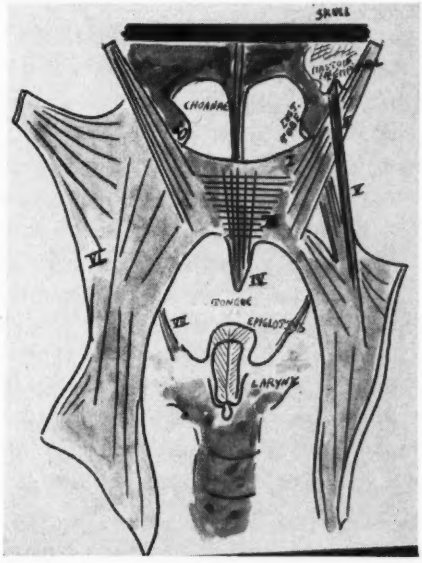


Fig. 13.—The velopharyngeal muscles, posteroanterior view. *I.* tensor veli palatini, *II.* levator veli palatini, *III.* palato-pharyngeus, *IV.* azygos uvulae, *V.* salpingo-pharyngeus, *VI.* superior constrictor pharyngi, VII. palatozlossus. (After Rouviere.)

GROWTH AND PHYSIOLOGY IN CONGENITAL CLEFT PALATE

The relationship of the face to the skull, changes from 1 to 9 during the first six years of life.[26–28]

Surgery should be postponed until normal growth and development are least disturbed by the operation. One of the chief reasons the cleft palate patient seeks care is for his speech. Speech is directly affected by a cleft palate. Dyslalia and marked rhinolalia (nasality) are invariably present in nonoperated patients. All vowels to a different degree and all consonants, except m, n, and ng, require

closure of the velopharyngeal sphincter. The sphincteric action of the velopharyngeal musculature is more or less complete, depending on the produced sound. This is accomplished by the contraction of the velopharyngeal musculature which raises the soft palate like a curtain upward and backward against the superior posterior constrictor pharyngi muscle which contracts along a lateral and anterior direction. The anterior displacement of the superior constrictor is usually greatest at Passavant's pad. This action is obtained by the simultaneous play of three groups of muscles (Fig. 13):

Group	Action
1. *Superior*	
Levator veli palatini and tensor veli palatini	Raise, tense, and pull the velum backward
2. *Inferior*	
Palatopharyngeus, palatoglossus, and azygos uvulae	Pull the soft palate downward, lengthen the velum, draw the tongue upward (palatoglossus), and shorten the velum (azygos)
3. *Posterior*	
Superior posterior constrictor pharyngi	
This muscle is composed of four groups of muscle fibers according to Oldfield:[29] (1) pterygopharyngeus, (2) buccopharyngeus, (3) mylopharyngeus, and (4) glossopharyngeus.	

This group of muscle fibers inserts on the median pharyngeal raphe. This quadrilateral muscle acts as a curtain along an anterior direction, it closes the posterior aspect of the rhinopharynx from the oral cavity by a lateral and anterior contraction. There are still many obscure points regarding the normal anatomy and physiology of the muscles of the soft palate. The elementary outline given here is only intended as a guide to understand some of the fundamental requirements of the speech appliance.

In congenital cleft palate, the sphincter muscles of groups 1 and 2 are interrupted and their action is reversed: 1. The superior group raises, tenses, and pulls the velum backward and, therefore, increases the width of the cleft. 2. The inferior group is even more affected. The posterior contact with the superior constrictor muscle cannot be obtained because the pathologic action of group 1 tends to shorten the velum and as it separates the muscles, it increases the size of the cleft, and prevents the downward pull of the inferior group. 3. The posterior lateral group is not involved. The posterior constrictor tends to hypertrophy.[30]

According to the size and the location of the cleft, the function of the musculature will be more or less affected. The physiology of speech is modified according to the extent of the deformity.

SPEECH PRODUCTION

Some fundamentals of speech production should be known to the prosthodontist. According to McDonald[24] speech results from several combined physiologic actions: respiration, phonation, resonation, articulation, and integration. All these single factors are important, for when coordinated by the central nervous system, they result in normal speech.

The lungs and the larynx produce the first two physiologic activities. The actual production of sound takes place in the pharynx, nose, and oral cavity. Resonation occurs in the oropharynx, oral, and nasal cavities. Generally satisfactory resonation of all vowels and consonants, except m, n, and ng, require a virtual closure of the rhinopharynx. The air stream must be cut off from the nasopharynx. This occurs by the sphincter action of the three muscle groups. The relative positions existing between the velum, tongue, and posterior pharyngeal wall during respiration, speech, mastication, and deglutition are complex and have been studied in detail by Schalit.[31]

Articulation is produced in the oral cavity. The tongue and the teeth, as well as the vault of the hard palate have an important function in speech production. The tongue, by constant changes in position against the teeth and the palate, modifies the direction and the volume of the air stream.

A cleft palate interferes with normal speech because of the anatomic abnormalities. The closure of the velopharyngeal sphincter is not satisfactory. Air leaks occur and rhinolalia results. The nasal resonance may affect all vowels to a different degree and all consonants, except m, n, and ng. Complete closure of the rhinopharynx is not essential for normal speech production.[24] Sounds like s, l, r, f, v, sh, and zh are usually markedly nasalized. The interference with proper articulation is superimposed on the rhinolalia. As clefts of the soft palate and hard palate are frequent, air escapes also through the hard palate into the nose; and therefore interferes with the articulation of plosive sounds like p, b, t, d, k, and g. These sounds are produced by the sudden release of air from the oral cavity. When an oronasal communication exists, the patient is unable to build up the intraoral air pressure necessary for the proper articulation of these sounds. Other sounds like s, z, ch, th, and n require proper approximation of the tongue to the anterior teeth and the lingual aspect of the hard palate. In Class III and IV clefts, considerable air leaks through the alveolar cleft. The anterior teeth are missing in many cases which further interferes with speech.

Normal mastication and deglutition are also markedly impaired. Foods and fluids penetrate into the nasal cavity, irritate the mucosa, and predispose to chronic rhinopharyngitis. The masticatory efficiency is lowered by the lack of proper muscle coordination, the malocclusion, the missing teeth, or teeth in improper occlusal contact. The vertical dimension has often collapsed, and abnormal muscle activites result from the efforts the patient makes to compensate for the absence of normal function. There is also, in some cases, a lack of coordination of the muscles of facial expression.

The greatest and most serious effect of abnormal speech, impaired deglutition, and disfigurement appearance is psychic. The moral and mental development of

the child is definitely influenced by the deformity. The orofacial cripple labors under a decided handicap and finds adjustment to school and society difficult.[2]

A good working knowledge of the basic anatomic and physiologic principles as they apply to the congenital cleft palate problem is necessary for diagnosing and treating these patients successfully.

DIAGNOSIS

Clinically, the patient is examined by all specialists concerned, and a treatment plan is outlined after a joint seminar discussion of each patient's problem. When prosthetic therapy is indicated, additional data are necessary for the accurate planning of the desired appliance.

Facial contour, tonus of the muscles of mastication and facial expression, vertical dimension, and lip length, width, and form are carefully studied. Intraoral examination of the teeth is performed carefully. The caries incidence, location of cavities, morphology of the teeth, the periodontal support, and the occlusion are recorded. The alveolar ridge, hard and soft palate, and mucobuccal fold are examined. The size, shape, depth, length, and condition of the mucosa of the soft and hard palate are surveyed. The soft palate is tested for function; flexibility, mobility, and tonus of the remaining velar muscles are checked, and swallowing is studied. Passavants' pad is outlined with a pencil, palpated, and tested for its relationship with the velar muscles at rest and in function. Diagnostic aids should include good extraoral and intraoral photographs and radiographs. Cephalometric films are useful to determine a possible collapse of the vertical dimension, centric occlusion, and the lateral outline of Passavant's pad when the posterior pharyngeal wall is painted with a radiopaque media. The relation of the obturator bulb may be checked accurately, as to its proper extension, with profile cephalometric radiographs when a radiopaque material is used on the pharyngeal surface of the speech bulb. Study casts are mounted on an adjustable articulator, and examined carefully before designing the appliance. The vitality of all teeth must be determined. When the information necessary for the proper planning has been obtained, the treatment of choice is selected and carried out to the detail.

Before any prosthetic appliance is contructed, the teeth, their supporting tissues, and the denture-bearing area must be in optimum health. Any pathosis (dental, periapical, or periodontal) should be eliminated. The abutment teeth are properly restored. As many teeth as possible are retained in the arch as long as they do not interfere with the construction, stabilization, and retention of the speech aid or other prosthetic appliance. Often it is necessary to prepare the denture-bearing area surgically. Interfering teeth, scar tissue attachments, low muscle insertions, secondary perforations and fibrous scars are corrected before the impressions are made. The teeth and the denture-bearing area should be prepared to give the best possible stability, balance, and retention to the speech appliance.

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ANNOUNCING

THE AMERICAN DENTURE SOCIETY PROSTHETIC ESSAY CONTEST

PRIZES WILL BE AWARDED to the two senior dental students who submit the best essays on prosthetic dentistry. The first prize is Five Hundred Dollars ($500.00) and the second prize is Three Hundred Dollars ($300.00). The purpose of the contest is to stimulate technical writing by dental students.

RULES

1. The contest is open to all senior dental students of American dental colleges.
2. Essays are to be on some phase of prosthetic dentistry.
3. Essays are to become the property of The American Denture Society. None will be returned.
4. The winning essays will be published in THE JOURNAL OF PROSTHETIC DENTISTRY.
5. Essays must be double spaced, on plain paper, with generous margins. No carbon copies or essays on onion skin paper will be considered.
6. Illustrations must conform to the standards of THE JOURNAL OF PROSTHETIC DENTISTRY.
7. Essays must be worthy of publication in THE JOURNAL OF PROSTHETIC DENTISTRY to qualify for a prize.
8. Essays must be postmarked on or before July 15, 1954 in order to receive consideration.
9. The judges of the contest are a special committee of The American Denture Society.
10. The decision of the judges is final.
11. Essays are to be clearly marked as "Contest Papers" and sent to: Dr. Carl O. Boucher, College of Dentistry, The Ohio State University, Columbus 10, Ohio.

For further information write to: Dr. Arthur L. Roberts, Secretary, American Denture Society, Aurora National Bank Bldg., Aurora, Ill.

News and Notes

ANNOUNCEMENTS

The Pacific Coast Society of Prosthodontists will hold its Annual meeting at the Olympic Hotel, Seattle, Wash., May 29 and 30, 1954.

The American Denture Society will hold its twenty-sixth annual meeting Nov. 5 and 6, 1954, at the di Lido Hotel, Miami Beach, Fla. Hotel reservations must be made through the Housing Bureau of the American Dental Association.

Vacancies exist in residencies in oral surgery and in prosthodontics at the Veterans Administration Hospital at Wood, (Milwaukee) Wisconsin. These residencies are to begin July 1, 1954. The residency in oral surgery is for three years; that for prosthodontics is for two years. Each of these are to be preceded by one year of internship. Both are approved for board examination. If interested please write for residency outline to: Chief, Dental Service, Veterans Administration Hospital, Wood, Wisconsin; or Marquette University School of Dentistry, c/o Dr. O. M. Dresen, Dean, 604 N. 16th Street, Milwaukee 3, Wis.

New York University College of Dentistry announces a special postgraduate course in "Complete Denture Prosthesis," June 7 to 18, 1954, and one on "Partial Dentures," June 7 to 18, 1954. These courses are scheduled daily from 9 A.M.

to 9 P.M. and include lectures and clinic experiences in theory and practice of prosthodontics. Short courses in "Periodontics" and "Pulp-Canal Therapy" also are offered during the month of June. A full or part time postgraduate course in Periodontia and Oral Medicine is offered under the direction of Samuel Charles Miller. The course will start Sept. 20, 1954, and continue for from one to four years. For further information about any of these courses write to the Secretary, Postgraduate Division, New York University College of Dentistry, 209 East 23rd Street, New York 10, N.Y.